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ABSTRACT

Presented is a resource book to be used with instructional kits for elementary school science students, grade 6. The individual units at this grade level are based on curriculum which has been developed by the National Science Foundation in the 1960s and revised to meet student and teacher identified needs in Anchorage, Alaska. Six units are included within this guide. Each unit lists kit and non-kit items, supplemental materials, teacher background information, and proposed schedule. Worksheet masters are also included. Unit topics include Kitchen Physics, Mealworms, Environment of Flowering Plants and Their Seeds, Properties of Water, Atoms and Molecules, and Batteries and Bulbs II. (CS)

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ELEMENTARY SCIENCE GUIDE

6TH GRADE

1978

SUPERINTENDENT OF SCHOOLS

ANCHORAGE SCHOOL DISTRICT

4600 DEBARR ROAD

ANCHORAGE, ALASKA 99504

SE 031 450

FOREWORD

This Resource Book has been prepared for use with instructional kits distributed through the Anchorage School District Science Center. These kits were developed by the Elementary Science Curriculum Committee under funding by ESEA Title IV B & C in response to student and teacher identified needs.

The individual units at each grade level are based on curriculum which has been developed by the National Science Foundation in the 1960's. The curriculum has been taught by thousands of teachers throughout the United States. The Anchorage School District adopted this curriculum and our Anchorage teachers have adapted it to fit our needs and our scope and sequence. The Anchorage School District is enthusiastic about this effort and believe that this guide and the Science Center will represent more effective and efficient ways of teaching science.

The process of curriculum planning and development requires the help of many teachers, principals and administrators. We appreciate the cooperation and assistance of everyone who has contributed to this project.

E.E. (GENE) DAVIS, ED.D
ASSISTANT DEPUTY SUPERINTENDENT

EED:dc

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The development of this guide represents the contribution of many talented people during the past two to three years. We are very grateful to the following people for the unique contribution each of them made in developing our science program.

The guide material was written by the following people:

1st trial edition 4-6 writing team summer 1977.

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The Jefferson County School District - Lakewood, Colorado - Harold Pratt and Marge Melle, Science Specialists.

The Minneapolis School District - Minneapolis, Minnesota - Joseph Premo.

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Outcome Statement . . . . . .

(To be taught in any sequence)

Kitchen Physics

Mealworms

Environment of Flowering Plants and Their Seeds

Properties of Water

Atoms and Molecules

Batteries and Bulbs II

OUTCOME STATEMENT

For Students Grades K-6 -- Science

The major outcome of science education in the Anchorage Schools is the development of scientifically literate citizens. A scientifically literate person is generally described as a person who:

- Understands enough of the fundamental concepts of the physical and biological nature of the world so that he/she may act responsibly.
- Possesses science skills and processes that give rise to facts and concepts.
- Possesses attitudes or values generally associated with science such as curiosity and respect for data.
- Uses science concepts, skills and values in making decisions as he/she interacts with other people and with his/her environment.
- Is aware of the interrelationship taht exists between cultural, philosophical, environmental, and social changes and scientific and technological advancements.

The role of the elementary school is to provide concrete, first hand experiences for students so that they may <u>begin</u> the process of becoming scientifically literate citizens. Because a child's mind changes in the manner it operates, and does not simply increase in capacity as it matures, the K-6 outcomes will be concrete and demand direct student observations. Nevertheless, these outcomes are important prerequisites for the later outcomes.

By the end of the sixth grade a student should be able to:

- Observe and describe a simple event using more than one sense.
- Record and share observations with others.
- Classify a set of objects.
- Collect and organize simple data.
- Interpret the meaning of simple data
- Set up a simple experiment to answer a question
- Read scientific materials critically.

OUTCOME STATEMENT (Continued)

- Demonstrate a basic understanding of the function of the ecosystem and his/her relationship to it.
- Demonstrate a basic knowledge of the systems of the human body.
- Demonstrate a basic knowledge of physical science concepts to which he/she has been introduced.

1 Each unit will have:
A. A listing of kit and non-kit items.
B. Supplemental materials list.
C. Teacher background information.
D. A schedule.

2 The units have been developed to be taught anytime throughout the year.

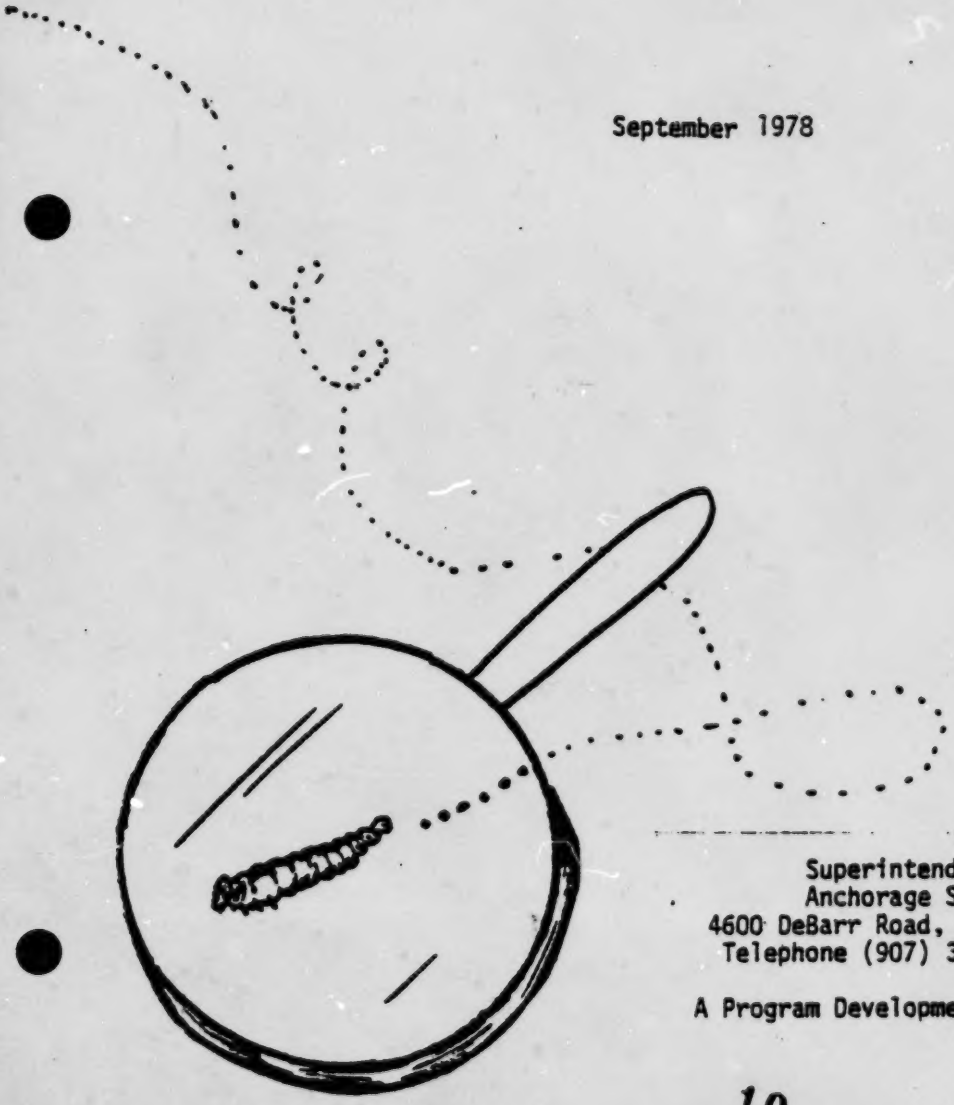
3 The approximate times needed for each unit are included to help you in your long range planning.

4 Worksheet masters are included in your guide for reproducing.

5 Call the Science Center if you have a problem.

TEACHER'S RESOURCE BOOK
FOR
MEALWORMS
GRADE 6

September 1978



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BEHAVIOR OF MEALWORMS

Grade 6

INTRODUCTION:

The lessons in this unit have been written so that your students will be able to carry out observations and experiments with mealworms, and draw conclusions based on their observations of the experiments.

It is based on the idea that children will achieve more when they become involved in the experiment. They will be able to see for themselves that certain results occur when simple experiments are performed.

At times, throughout the unit, you will want the students to proceed individually and at their own speed. At other times you will want the whole class to work on the same activity.

The lessons are designed to allow your students to follow many side paths for experimentation. For example, when you reach questions of mealworm's food preferences, you may wish to let your students explore several ideas besides the activities mentioned in the unit. Your schedule and the student's interest should be the only limits to this kind of creative work.

You will probably find it best to divide your class into working groups of two and four students. This arrangement will enable the students to work and converse easily as they discover new things. This arrangement will allow you to become a "Classroom Manager" rather than a source of all information. You will be free to move from group to group, encouraging the students to answer their own questions by experimentation.

Teachers who have used a discovery approach to teaching have found it important to have four points well in mind before beginning each lesson:

1. Lead-off Questions
2. Follow-up Questions
3. Activities
4. Discussion Questions

If you can proceed with these ideas you should find the unit of work exciting for both you and your students.

Student pictures, data tables, reports, talks are all part of student involvement for this unit. It is important to blend together the activities of each lesson with these reporting techniques.

EVALUATION:

It is difficult to design evaluative devices for the experimental science described in this unit. If you allow your students the freedom to explore you will never be sure what has happened until it does. If you do feel that evaluation is needed, two possible directions can be followed:

a. Observation - This is perhaps the most natural form of evaluation. If you use observation techniques for the unit of work, it will be necessary for you to move from group to group, asking questions and listening to your students. Watch each student closely as he or she applies what they have learned to new situations.

b. Data Sheet - This sheet can offer a more formal kind of evaluation. Consult pp. 35-37 of the teacher's manual.

SCHEDULE:

This unit is based entirely on the E.S.S. unit "Behavior of Mealworms". Activity Sheets are provided with the kit with references to the teacher's manual and the unit objectives. Six of the activities are essential and can be completed in three weeks. The time period could be broken into 45 minute periods two or three times each week. Six activities are optional. Feel free to do some or all of the optional activities. If you do all twelve activities you should expect to take five or six weeks. Please ask for an extension beyond three weeks as soon as possible.

If you plan to have students carry on experiments at home with the mealworms it is wise to send a letter home to the parents first.

Care of mealworms is given on p. 43 of the teacher's manual. Be sure you emphasize to the students never to do anything to their mealworms that they wouldn't want done to themselves. Please put the mealworms back in their container when the science lesson is over.

This packet lists all lesson

This packet lists all lessons in order with the corresponding activity sheet numbers, unit objective numbers, and page location of each lesson in the E.S.S. Teacher's Manual.

Items with * are essential.

*Activity 1 Watching Mealworms
Teacher's Manual pp. 1-6 (E.S.S.)
Unit Objective #1

*Activity 2 How do Mealworms walk?
Teacher's Manual p. 8 (E.S.S.).
Unit Objective #1

Activity 3 Mealworm races
Teacher's Manual p. 8 (E.S.S.)
Unit Objective #1
(can be run on white paper or on several colors.)

*Activity 4 Food preferences of Mealworms
Teacher's Manual p. 8, 10 (E.S.S.)
Unit Objective #2

*Activity 5 Life cycle of a Mealworm
Teacher's Manual p. 43-45 (E.S.S.)
Unit Objective #3

*Activity 6 What is the best way to make a Mealworm back up?
Teacher's Manual p. 24-27 (E.S.S.)
Unit Objective #4

Activity 7 Straw Battle = Which is the stronger Mealworm?
(Students put a mealworm in both ends of a straw and observe their behavior.)
Unit Objective #4

*Activity 8 How does a Mealworm find bran?
Teacher's Manual p. 16-19 (E.S.S.)
Unit Objective #6

Activity 9 Will Mealworms go to meal or sawdust?
Teacher's Manual p. 16-19 (E.S.S.)
Unit Objective #6

Activity 10 T Maze. Does a Mealworm prefer dark or light?
Teacher's Manual p. 11-12, 32 (E.S.S.)
Unit Objective #6

Activity 11 What color does a Mealworm like best?
Teacher's Manual p. 22 (E.S.S.)
Unit Objective #6

Activity 12 Does a Mealworm stay under things becaues it likes the dark or because it likes the feel of weight on its back?
Teacher's Manual p. 33 (E.S.S.)
Unit Objective #6

Additional ideas to use:

1. Trace paths of mealworms by following with a pencil.
2. Have students write stories about mealworms.
3. Teach elementary statistics (range, mode, mean and median using group mealworm race data.)
4. Using statistics, let students experiment to see if older larger mealworms run faster on the average than younger smaller mealworms.

UNIT OBJECTIVE 1. Given a mealworm (or other animal) to observe, the student will describe the characteristics of the organism.

Evaluation Objective	Goal Area
B. The student will identify three or more anatomical characteristics of an observed organism.	Rational Thinking Process (Observation)
B. The student will differentiate among the parts of a mealworm's body.	Concepts
I. Given an organism to observe, the student will describe at least three quantifiable characteristics (e.g., length, number of segments, number of legs, number of antennae).	Rational Thinking Process (Observation)
B. The student will describe the eating habits of mealworms.	Rational Thinking Process (Observation)
A. Given a list of observed and inferred characteristics, the student will make discriminations between fact and inference.	Rational Thinking Process (Classification)
I. The student will record his observations of an organism by drawing illustrations.	Rational Thinking Process (Data Collection and Organization)
I. The student will observe and record locomotion behavior of the mealworm (e.g., how fast it moves, in which direction it turns, whether it goes up or down when placed on a slant.)	Rational Thinking Process (Observation, Data Collection and Organization), Communication.

UNIT OBJECTIVE 2. The student will investigate conditions that affect the growth of a colony of mealworms.

Evaluation Objective	Goal Area
I. The student will control environmental factors such as light, temperature, humidity, or chemicals and record the resulting changes in a mealworm's behavior.	Rational Thinking Process (Variable Identification and Control)
B. The student will identify the kinds of food necessary for a mealworm's growth.	Rational Thinking Process (Observation)

UNIT OBJECTIVE 3. The student will demonstrate an understanding of the life cycle of the mealworm.

Evaluation Objective	Goal Area
B. The student will distinguish between the egg, larval, pupal, and adult stages of a mealworm.	Concepts
I. The student will make drawings illustrating the various stages of development of a mealworm.	Rational Thinking Process (Data Collection and Organization), Communication

---

UNIT OBJECTIVE 4. The student will investigate the "backing up" movement of mealworms.

Evaluation Objective	Goal Area
I. The student will make and test a hypothesis about how to make mealworms back up.	Rational Thinking Process (Making and Testing Hypotheses)
I. The student will record quantitative data from his investigation concerning the backing up movement of mealworms.	Rational Thinking Process (Data Collection and Organization)
I. Given a chart of data related to mealworms' backing up behavior, the student will infer trends from the data.	Rational Thinking Process (Inference and Prediction)
I. Given a list of various methods which might be used to make a mealworm back up, the student will group similar methods and identify a label for each group.	Rational Thinking Process (Classification)

UNIT OBJECTIVE 5. The student will investigate the exploratory movements of mealworms (or of other organisms).

Evaluation Objective	Goal Area
I. The student will identify variables involved in his investigations of the exploratory movements of an organism.	Rational Thinking Process (Variable Identification and Control)
I. Given a paragraph containing data about an organism's exploratory behavior, the student will organize the data into a simple chart.	Rational Thinking Process (Data Collection and Organization)
A. Given a chart of data about the exploratory movements of an organism, the student will select statements of trends that are supported by the data.	Rational Thinking Process (Inference and Prediction)

UNIT OBJECTIVE 6. The student will investigate the senses of a mealworm or other organism.

Evaluation Objective	Goal Area
B. Given a magnifying lens or microscope, the student will make drawings of the organism's anatomical detail which might be related to sight and touch.	Rational Thinking Process (Data Collection and Organization), Communication
I. Given observations of an organism's behavior and its anatomical detail, the student will pose hypotheses about the structure and function of possible sensory receptors.	Rational Thinking Process (Making and Testing Hypotheses)
I. Given a hypothesis that a mealworm feels a wall with his legs, the student will describe a way to test this hypothesis.	Rational Thinking Process (Making and Testing Hypotheses)
I. Given materials, the student will construct walls and mazes to be used in sensory experiments with mealworms.	Manipulation
I. The student will devise and carry out tests to observe changes in mealworms' behavior when introduced to a variety of stimuli.	Rational Thinking Process (Process Synthesis)
I. The student will conduct a test to determine a mealworm's ability to perceive light and/or distinguish colors.	Rational Thinking Process (Process Synthesis)
I. The student will conduct a test to determine a mealworm's sense of smell.	Rational Thinking Process (Process Synthesis)

UNIT OBJECTIVE 7. Given descriptions of experiments conducted with animals, the student will analyze the results of the experiments.

Evaluation Objective	Goal Area
B. Given descriptions of experiments, the student will identify observations that are not clear.	Rational Thinking Process (Observation)
I. Given desctiptions of experiments, the student will identify procedures that are not clear or not complete.	Rational Thinking Process (Variable Identification and Control)
I. Given descriptions of experiments, the student will identify variables that were not controlled.	Rational Thinking Process (Variable Identification and Control)

I. Given descriptions of experiments, the student will identify conclusions that are inconsistent with reported data.	Concepts
I. Given descriptions of experiments, the student will identify alternative conclusions which could explain the data.	Rational Thinking Process (Interference and Prediction)
I. Given desctiptions of experiments, the student will describe procedures that could improve the experiment.	Rational Thinking Process (Making and Testing Hypotheses)

UNIT OBJECTIVE 8. The student will demonstrate ways to care for a mealworm or other organism.

Evaluation Objective	Goal Area
B. The student will demonstrate the least harmful ways of handling an organism.	Attitudes

ACTIVITY SHEET #1

WATCHING MEALWORMS

1. What I found out:

2. What I did:

What the mealworm did:

19

ACTIVITY SHEET #2

HOW DO MEALWORMS WALK?

1. In what order does it move its legs?

2. Does a certain mealworm turn more often to the right or to the left?

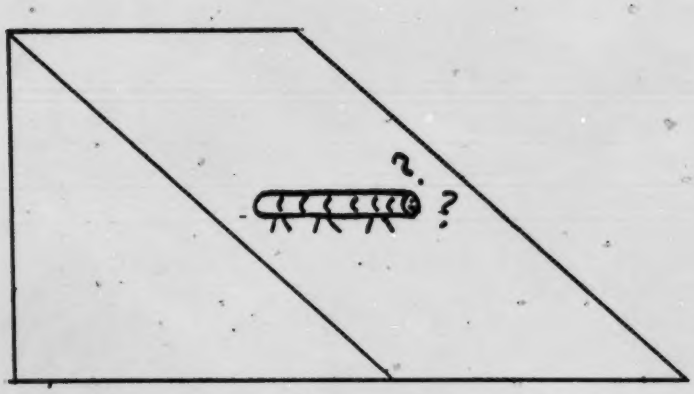
3. Can you make a mealworm go in a straight line?

4. How does a mealworm walk on the moving turntable of a record player?

*5. How far does a mealworm go in a minute? (races)

6. How fast can the fastest mealworm go?

7. If placed sideways on a slant, do mealworms walk up more than they walk down?



ACTIVITY SHEET #3

MEALWORM RACES

For mealworm races you will need a data sheet, a race course of each color, 2 rulers to act as walls, some mealworms in a container, a flat place to work, and a clock with a second hand.

1. Choose a partner. One of you is starter, the other is timer-recorder. Go where you can see the second hand of a clock. Place the race track on a level place.

2. Predict how many centimeters you think your mealworm will crawl in one minute. Write prediction on the Mealworm Race Sheet.

3. Starter puts mealworm's head gently on starting line. Timer holds rulers on either side to make a path for the worm to follow. When timer says GO, starter lets go of mealworm. After 15 seconds, the timer says STOP.

4. Note how far the mealworm has crawled. Measure to where its head is. Record the distance.

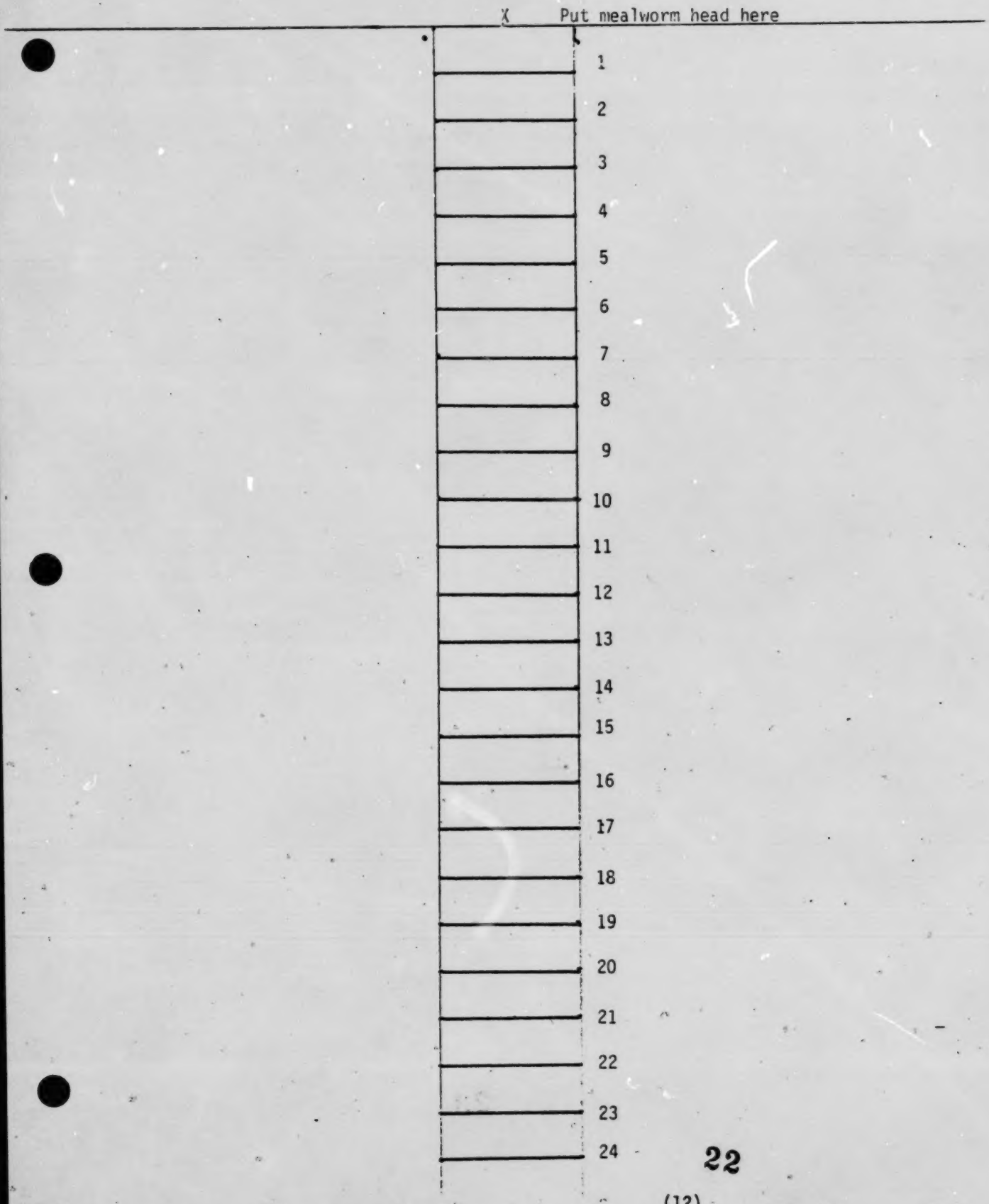
5. Make four 15 second trials. That makes one minute. Add up all four distances to find out how many centimeters your mealworm crawled in one minute.

6. Do the same for other colored race tracks if you have them.

7. Record your result with other students on a chart. Put the mealworm back in its food. Put the race tracks back.

ACTIVITY SHEET #3

MEALWORM RACE TRACK



ACTIVITY SHEET #3

MEALWORM RACE SHEET

NAME_____

WORM I.D.	PAPER COLOR	PREDICT 1 MIN.	TRIAL #1 15 SEC.	TRIAL #2 15 SEC.	TRIAL #3 15 SEC.	TRIAL #4 15 SEC.	TOTAL PER MINUTE

ACTIVITY SHEET #4

FOODS MEALWORMS LIKE	FOODS MEALWORMS DON'T LIKE
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.
8.	8.
9.	9.
10.	10.
11.	11.
12.	12.
13.	13.
14.	14.

Do mealworms like water?

What did you do to find out?

ACTIVITY SHEET #5

LIFE CYCLE OF A MEALWORM

DRAW AND LABEL THE STAGES OF GROWTH OF A MEALWORM.

25

ACTIVITY SHEET #6

WHAT IS THE BEST WAY TO MAKE A MEALWORM BACK UP?

WHAT WAS DONE	TOTAL TIMES TRIED	TOTAL TIMES WENT BACKWARD	RANK FROM BEST WAY TO WORST
1.			
2.			
3.			
4.			
5.			

(16)

ACTIVITY SHEET #7

STRAW BATTLE

Put a mealworm in both ends of a straw facing each other. Observe the behavior of the mealworms as they meet inside the straw. Can you tell which is the stronger mealworm?

ACTIVITY SHEET #8

FOLD UP

FOLD UP

FOLD UP

X Start mealworm here.

FOLD UP

ACTIVITY SHEET #9

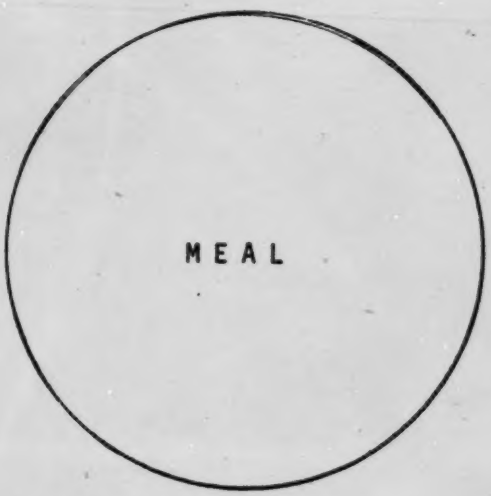
WILL MEALWORMS GO TO MEAL OR SAWDUST??

I PREDICT THAT:

MEALWORM	1.	2.	3.	4.	5.
Number of trials:					
Times went to the meal:					
Times went to the sawdust:					
Times to neither:					
CONCLUSION: I found out that:					

ACTIVITY SHEET #9

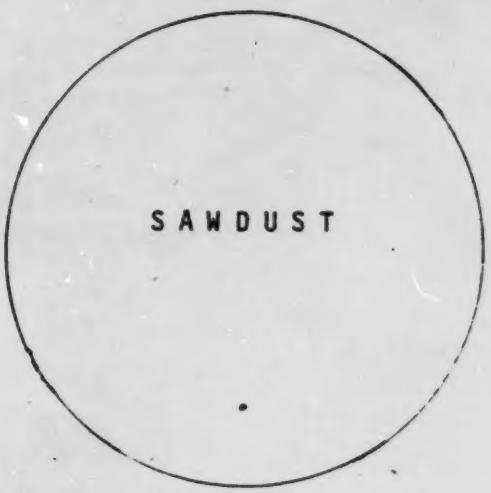
FOLD UP



FOLD UP

X <------place mealworm on arrow

FOLD UP

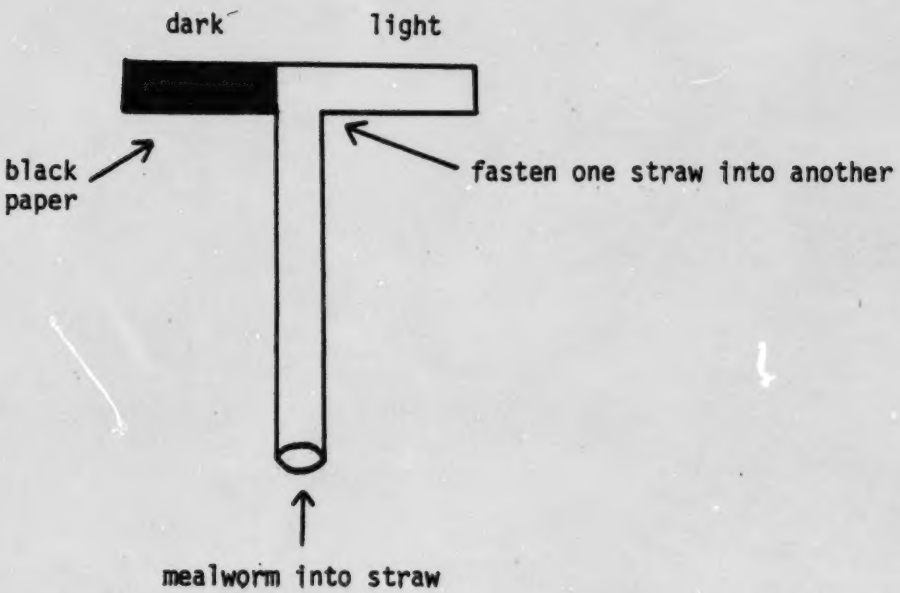


FOLD UP

ACTIVITY SHEET #10

T MAZE

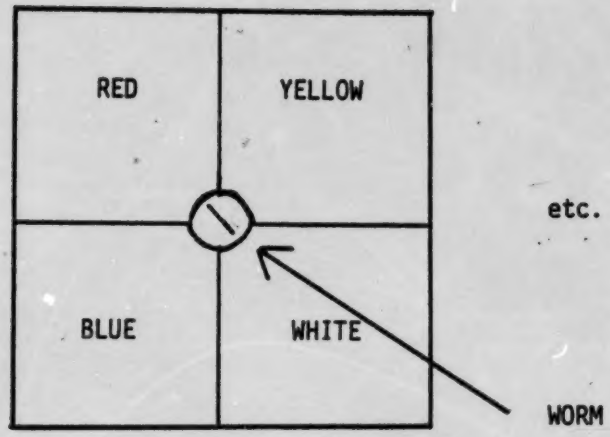
T=



Will it go to light or dark?

ACTIVITY SHEET #11

What color does a mealworm like best?



NUMBER OF TIMES WENT TO EACH COLOR

RED	
YELLOW	
BLUE	
WHITE	

ACTIVITY SHEET #12

DOES A MEALWORM STAY UNDER THINGS BECAUSE IT LIKES THE DARK OR BECAUSE IT LIKES THE FEEL OF WEIGHT ON ITS BACK??

I predict that:

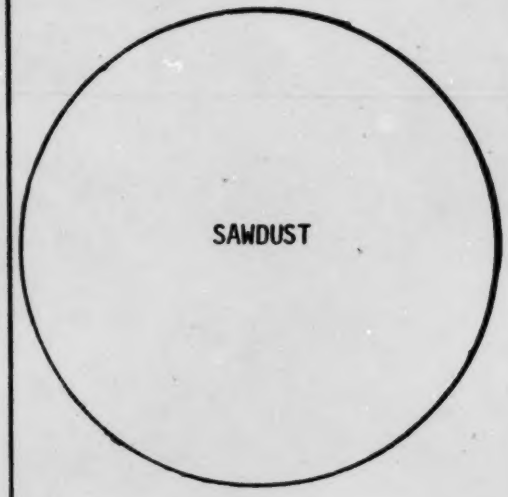
TOTAL TRIALS	TIMES STAYED UNDER SAWDUST	TIMES STAYED UNDER CELLOPHANE
(23)		

CONCLUSION: I found out that my mealworm:

ACTIVITY SHEET #12

FOLD UP

FOLD UP



FOLD UP

(24)

FOLD UP

37

38

MATERIALS FOR A CLASS OF 36

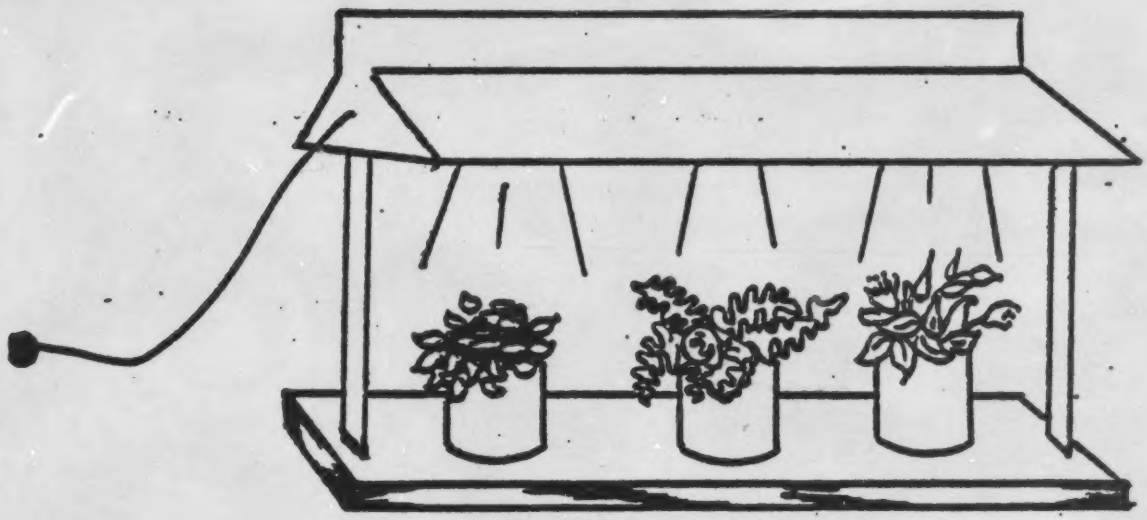
KIT	NON KIT
1 Container of mealworms	36 Rulers
36 Hand lenses	Clock with second hand
Food	Sawdust
100 Film cans + lids	Construction paper
1 Roll celophane	
Straws	
18 Race tracks	
1 Teacher's Manual	
1 Set of laminated illustrations	
36 Copies of Activity Sheets*	
bran	

*Consumable. Students may make notebooks from these activity sheets. Please return all sheets that are clean or unused.

TEACHER'S RESOURCE BOOK
FOR
ENVIRONMENT OF FLOWERING PLANTS AND THEIR SEEDS

GRADE 6

Trial Edition
September 1977



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FOREWORD

This Resource Book has been developed as a result of the Elementary Science Curriculum Committee responding to the needs of teachers and schools. A Science Center has been established including kits to be rotated and used by the elementary schools. This Resource Book is to assist the teachers to utilize the kit on "Environment of Flowering Plants and Their Seeds" at the 6th grade level. Special thanks goes to the Highline School District in Washington which helped immensely throughout the development of the Science Center, and to the Jefferson County School District in Lakewood, Colorado, the Minneapolis School District in Minnesota, and the Fairfax School District in Virginia, for sharing ideas and being supportive. Also, appreciation goes to Audio Visual Services, especially to Marilynn Scott, whose support made the project possible.

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ENVIRONMENT
OF
FLOWERING PLANTS AND THEIR SEEDS

Grade 6

PART I

This unit was organized to fit the needs of 6th grade students. Undoubtedly many of the students have been introduced to plant study earlier in the elementary school and many of the activities may have already been done by some. The way it is presented, however, can serve as a review while learning to apply the scientific method of study. The teacher is by no means required to follow the plans as they are presented. Each student may devise his or her own method of study and some will probably come up with many more creative ideas. By all means let them explore and test.

Since this unit involves time in between observations for growth, etc., it affords an excellent opportunity for research and class discussions.

Each worksheet is intended to reinforce skills in observing, note-taking, graph-making and experimentation.

The background information is provided for the teacher. The same material can be found in some student textbooks if a text is needed. Your school library is an excellent resource center.

THE FIRST 5 WORKSHEETS ARE STRUCTURED TO ENSURE THOSE STUDENTS WHO LACK ORGANIZATION AND EXPERIMENTAL SKILLS. WORKSHEET 6 CAN BE USED AS AN EVALUATION IF SO DESIRED AS THE STUDENT IS LEFT TO DEVISE HIS OWN EXPERIMENT.

IF YOU HAVE THE MEANS TO CONTROL TEMPERATURE, EXPERIMENTS CAN BE SET UP FOR THIS. IF NOT, ABOUT THE ONLY THING YOU CAN DO IS TRY PLANTS IN THE COLD, AT ROOM TEMPERATURE, AND ON TOP OF OR CLOSE TO A HEAT VENT OR RADIATOR. THERMOMETERS HAVE BEEN PROVIDED.

DEPENDING ON STUDENT INTEREST AND TIME, PART II HAS BEEN INCLUDED. IF BY CHANCE YOUR CLASS IS WELL-VERSED AND HAS WORKED WITH PLANTS, YOU MAY ONLY WANT TO DO PART II. THIS PART HAS TO DO WITH THE ANATOMY OF THE PLANT AND HOW ALL CELLS, ORGANS AND SYSTEMS WORK TOGETHER FOR PLANT SURVIVAL IN ITS ENVIRONMENT.

Schedule - may take up to 5 weeks.

WORKSHEET #1

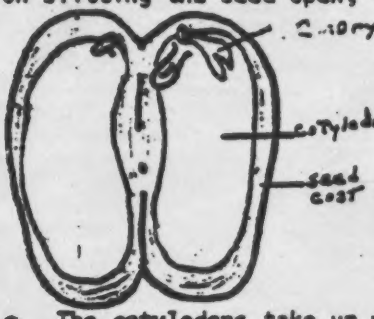
OBJECTIVE: The student will observe seeds and be able to identify the parts.

PROCEDURES:

1. It is better for the teacher to soak the seeds to be used. This may be done by soaking paper towels and laying the towels in shallow containers over night. The large lima bean is best suited for this because of its size. At the same time soak 10-12 seeds/beans for worksheet #2.

2. Instruct students to slit their seed-coat lengthwise with a single edged razor blade. A paper plate can be placed under the seed and caution students in the safety of using a razor blade.

3. On slitting the seed open, the seed will look similar to this:



a. A seed coat covers the seed. When water is absorbed, the coating swells and breaks. In soil the seed absorbs water and does the same thing.

b. The embryo looks like a miniature plant. Looking closely you can see the stem top (looks like two leaves) and a root tip.

c. The cotyledons take up most of the space and serve as food for the small plant.

d. The root tip develops into the root and the stem tip into the stem and leaves.

4. After students have had an opportunity to examine seeds, let them fill in their predictions, then discuss.

KIT	NON-KIT
200 Lima beans	Paper towels
36 Single edged razor blades	Shallow container
Saran wrap	
Light source	

TEACHER INFORMATION
WORKSHEET #2

TIME: 3-5 DAYS

PROCEDURE A:

1. Instruct students to make daily observation of the germinating seeds. They should be sprouted in 3-5 days. Encourage them to observe closely and take notes.

2. Throughout germinations the students should note the following which can be brought out in class discussions:

   a. Root tip goes down regardless of positions and sprouts first. (This is not true in all seeds, which will be observed later.)

   b. Stem tip grows up.

   c. Cotalydon becomes smaller. If students measure this they will note this.

PROCEDURE B: Class discussion should be related to student predictions. Then some questions such as "What is needed for a seed to germinate?" "Does it need light?" (Obviously not since seed is underground) ...water?" ...warmth?" ....oxygen?" (Some ways to test this is to place seeds under water or light a candle and place a jar over both seed and candle. (Seal bottom with vaseline.) Some students may want to experiment more with this.

This would be a good time to present the names for seed parts.

KIT	NON - KIT
180 - 360 Lima beans	Paper towels
18 Candles	Vaseline
Light source	Jars

TEACHER INFORMATION

WORKSHEET #3

TIME: 5 DAYS

OBJECTIVE: Student will learn that a seed needs all its parts to grow into a healthy plant, and how to collect and plot data.

PROCEDURE: Instruct pairs of students to separate 3 or 4 seeds into the following parts: cotyledon, cotyledon and embryo, embryo, as well as 1 complete seed. Measure all parts with a metric ruler. If a round container is lined with moist paper towelling and seeds and parts are placed between towel and glass, students can observe and measure. A paper plate can be used also.

Have students fill in chart and plot information on a graph using four different colors. 0 = DAY 1.

ADVANCE PREPARATION - Soak 7 beans per team 24 hours before using .

CONCUSION: Have students write conclusion.

MATERIALS NEEDED:

KIT	NON - KIT
110 Seeds	
18 Rulers	
18 Containers	
18 Razor blades	

TEACHER INFORMATION
WORKSHEETS 4, 5, 6, 7

TIME: 2-3 WEEKS

OBJECTIVES:

1. Students will set up controlled experiments, record observations and plot data.

2. Students will see the necessity of light, food, water and warmth for good plant growth (environment).

PROCEDURE A:

1. This section gives the student the opportunity of setting up his/her own experiment to test environment and plant growth. At this point you may not want to use the worksheets. Students can devise their own. They should have a plan, however, before they start.

2. Experiments will be to test soil, light, water and warmth.

   a. Plants with good potting soil, packed loose.

   b. Plants without soil.

   c. Plants with sand.

   d. Plants with rocks or pebbles.

   e. Plants with varying amounts of light, as well as colored light.

   f. Plants with varying amounts of water.

   g. Plants with varying amounts of heat.

PROCEDURE B:

Begin a class discussion reviewing the steps of scientific investigation.

1. Recognize and define the problem.

2. Collect information related to problem.

3. Form an idea (hypothesis) as to how the problem may be solved.

4. Experiment to prove or disprove the idea.

5. Observe the experiment.

6. Organize and record data from the experiment.

7. Draw conclusion from data.

If the students devise their own experiments, have them check to see if they have devised ways to follow the scientific steps. Experiments may or may not include all the steps but should include: (1) Define Problem, (2) Solve Problem from Data Collected During Study of the Problem. Pictoral graphs are an excellent way for students to "see" results. It also affords them the opportunity of organizing data, which is a skill in itself.

Some of your students may not have the skills to do the above, some may be well-versed in the skills needed to carry on the experiments. The purpose of the worksheets is to help the student develop these skills. Some students may do quite well on their own. Let them devise their own. Class results can be compared.

PROCEDURE C:

The maturity of your students and skills they possess will affect the way in which you want to handle worksheets 4, 5, 6, 7. Available space for plants will also be a factor; time also. If the experiments lag, students become disinterested, so it is better to keep things moving.

Following are listed some ideas which you may or may not want to use.

1. Students can be divided into four groups and each group experiment with one of the four experiments. It is advisable, if at all possible, to divide the four groups into teams of 2. This allows for class discussions and comparison of results.

2. Students can do all four experiments themselves. This will depend on you--if you think your students (and some may) can handle four sets of data at the same time, and some may, let them.

The results, however, should be completed at about the same time. Some students may want to extend experiments over a longer period of time. This can be done on their own.

SOIL: Soil contains the necessary minerals, water, and gases that a plant uses in order for its growth. Soil contains pockets which allow water and air to be trapped. The water is a solvent for the minerals contained in the soil. One experiment allows the student to observe the difference between packed soil and loosely packed soil, seeds planted with no soil, in sand and pebbles. Of course, there are plants which thrive in sand, only in water, etc.. But these are particular plants.

WATER: Allows students to experiment with particular amounts of water. A plant will not survive with too little water or too much water.

LIGHT: Allows students to experiment with varying amounts of light as well as colored lights. Experiments must be carried on long enough for students to see the effects. Also an optional section allows experimentation with leaves and chlorophyll.

TEMPERATURE: Allows students to experiment with temperature and growth. This may be difficult to control excepting to measure freezing, room temperature and hot.

MATERIALS NEEDED

WORKSHEET #4

KIT	NON-KIT
720 Seeds	Towels
72 Containers	
Soil	
Sand	
Pebbles	

WORKSHEET #5

KIT	NON-KIT
90 Containers	
Soil	
Light source	

WORKSHEET #6

KIT	NON-KIT
220 Seeds	Water
Soil	
72 Containers	

WORKSHEET #7

KIT	NON-KIT
18 Thermometers	
72 Containers	
Soil	

WORKSHEET #1

NAME_____

WHAT'S INSIDE A SEED?

PART A: Obtain a seed. With a single edge razor, slit the seed lengthwise. Examine closely, using your hand lens.

PART B: Draw a picture of your seed and its parts.

PART C: Predict what each part will become if you plant the seed. Which will grow up? Which will grow down? All living things need food. Where will the seed get its food to grow?

_____

_____

_____

_____

_____

_____

_____

PART D: Soak 2 paper towels. Ring out excess water. Place 10-12 seeds on the towel. Place on a paper plate. Place the seeds in different positions (sideways, upside down, rightside up). Cover your seeds with saran wrap and place under a light source in a warm place.

WORKSHEET #2

NAME_____

WHAT HAPPENS WHEN THE SEED GERMINATES?

PROCEDURE A: Observe closely all the seed parts' growth. Record date and measurements. Keep your seeds moist.

DATE:_____

DATE:_____

DATE:_____

DATE:_____

WORKSHEET #2 continued

WHAT HAPPENS WHEN THE SEED GERMINATES?

DATE: _____

_____

_____

_____

_____

_____

WORKSHEET #3

NAME_____

DOES A SEED NEED ALL OF ITS PARTS TO GROW?

PART A: Dissect a seed as shown on the observation chart which is attached. Plant seed parts after measuring length of each.

PART B: Make daily observations and record lengths.

PART C: Make a graph plotting height in mm against days.

Use 0 = Day of planting

Use a different color for each part planted.

PART D: CONCLUSION?_____

_____

_____

_____

_____

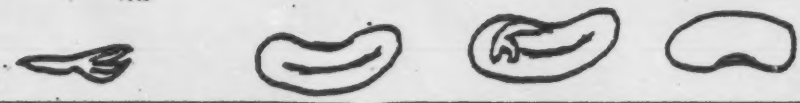
_____

_____

WORKSHEET #3 LOG

DATE PLANTED_____ NAME_____

Record the length of the seed parts in your experiment.



Day after planting	Embryo	Cotyledon	Embryo and 1 Cotyledon	Whole Bean
0 = Planting Day				

YOU GRAPH THE 4 SETS OF RESULTS IN 4 DIFFERENT COLORS.

WORKSHEET #4

NAME_____

SOIL USE IN PLANT GROWTH

FOOD FOR THOUGHT: The environment in which you live supports certain types of plants, better than other types. What does a plant receive from soil? What part of the plant utilizes the soil? Why do farmers plow? Why is weed control important? Can healthy plants survive and reproduce without soil? The following experiments will help you answer the above questions for the particular plants you will be working with.

PROCEDURE A:

Germinate the seeds of your choice. Thirty to forty seeds should insure you of enough plants.

Container #1: 25-30 mm of soil/5-10 seeds placed between container wall and dirt.

Container #2: Line in side wall with paper towelling. Place seeds between towels and wall.

Container #3: 25-30 mm of sand. Plant seeds between sand and wall of container.

Container #4: 25-30 mm of pebbles. Plant seeds between pebbles and container wall.

Remember what you are testing.

- What is the problem?
- How are you testing this?
- What must you do to make sure you test for only one thing?
- What about light, warmth, and water?

Decide what you will do about the above.

PROCEDURE B:

Make daily observations and measurements. Be alert. How many observations can you make?

WORKSHEET #4 CHART

DAILY OBSERVATION WORK CHART

DATE	Container 1	Container 2	Container 3	Container 4

15

57

58

WORKSHEET #5

NAME_____

WHAT EFFECT DOES LIGHT HAVE ON YOUR PLANTS?
WHAT ABOUT COLORED LIGHT?

FOOD FOR THOUGHT: Is light important for all plant growth? What does a plant receive through light? What is energy? Can a plant live and reproduce with a very little light? Does a seed need light to germinate? What happens to leaves?

PROCEDURE A:

Use seeds which have been soaked and starting to germinate. Think about what you are going to test. What things do you need to control? What do you do about soil, water, and temperature? Make a list of what you will do to your plants.

PROCEDURE B:

You might do the following:

Using 5 containers, place soil and water (Should you use the same amount?) plant your seeds (Should you use the same number?).

Container #1 0 light
#2 30 minutes
#3 3 hours
#4 6 hours
#5 24 hours

Make daily observations. Record.

PROCEDURE C:

Devise a test for the effects of a dim light and a bright light (optional).

PROCEDURE D:

Perhaps one or two students would like to set up an experiment testing colored light and plant growth. This can be done by planting seeds in a container and covering with colored cellophane. Can you think of a way to test if a plant prefers white light?

Use the chart to record data. REMEMBER - A plant has many parts to observe.

WORKSHEET #5 CHART

DAILY OBSERVATION WORK CHART

DATE	Container 1	Container 2	Container 3	Container 4

60

61

WORKSHEET #6

NAME_____

WATER USE IN PLANT GROWTH

FOOD FOR THOUGHT: You have undoubtedly learned that all living things need water to live. What does a plant use water for? What effect does too much water have on a plant or seed? Why doesn't a seed need water before it germinates? How does water help a seed to germinate? How long do you think a seed can be kept and still germinate?

PROCEDURE A:

What things will have to be kept the same in your experiment? Choose the seeds you wish to experiment with and devise a plan for controlling water. You are on your own for this one. When you have your plan, show it to the teacher and proceed! Don't forget note-taking on observations.

ENVIRONMENT OF FLOWERING
PLANTS AND THEIR SEEDS

Grade 6

Supplemental List

Films:

F-3180 Plants and Animals Share Space and Food

F-3189 How Seeds Are Made

F-3222 Container Gardens: Terrariums and Bottle Gardens

Books:

Texts:

1974 - People,Concepts,Processes, McGraw-Hill, Pages 66-75

1975 - Concepts in Science, Harcourt, Brace, Jovanovich, Pages 48-80

TEACHER'S RESOURCE BOOK

FOR

ATOMS AND MOLECULES

GRADE 6

September 1978

Superintendent of Schools
Anchorage School District
4600 DeBarr Road, Anchorage, Alaska 99504
Telephone (907) 333-9561, Extension 231

A Program Development Division Production

ATOMS AND MOLECULES

Grade 6

KIT

35 pill boxes
35 objects
5 candles
Matches
125 vials
35 plastic containers
1 package splints
55 medicine droppers
3 boxes cornstarch
3 boxes talc
3 boxes baking soda
3 boxes baking powder
3 quarts white vinegar
3 bottles iodine
17 10 ml. graduated cylinders
Copper sulfate - 1 lb.
Rochelle salt - 3 lbs.
Alum - 2 lbs.
Chrome alum - 2 oz.
Sodium carbonate (washing soda) - 2 lbs.
Magnesium sulfate (Epsom Salts) - 3 lbs.
Salt - 1 lb.
Sugar - 3 lbs.
Cream of Tartar - 2 lbs.
Anhydrous Copper Sulfate
10 petri dishes
20 microscope slides
Hot plates
10 beakers
5 stereoscopes
18 hand lenses
1 box toothpicks

SUPPLEMENTAL MATERIALS LIST

Films:

F - 547	Atomic Energy: Inside the Atom
F - 558	Controlling Atomic Energy
F - 2075	Energy: The Nuclear Alternative
F - 500	Metals and Non-Metals
F - 856	Equilibrium
F - 3403	Matter and the Molecular Theory

ATOMS AND MOLECULES

Grade 6

INTRODUCTION:

Chemistry is the study of the composition of matter, the properties of matter and the changes in composition of matter. Needless to say, your children do not have this understanding. More important, there is no reason why they should. However, they do know their world is made up of "stuff" and when you put "different stuff" together something new might be made. They have observed mixing "stuff" such as milk and flour; water and plaster paris; a candle burning; the fizz when a bottle of pop is opened. These are all examples of matter undergoing change. In this unit of work the children will be asked to mix materials together and really look at what happens. From this experience they will gain early understandings of the things matter is composed of.

The unit is divided into two general parts of 6 lessons which will allow your students to observe, collect data, discuss and begin to understand that matter (stuff) is made of small particles which cannot be individually seen, but can be worked with just the same. Your students will be able to relate changes in chemical and physical properties and, perhaps most important, will be involved in investigating science. You may want part of your students to begin the unit with Lesson VI since it will take some time for the crystals to grow.

RATIONALE:

The conceptual threads promoted in this unit of work extend those gained by the students at grades 2-5. You may want to take a look at what was done at grades 2-5. Your principal has the units so feel free to take a look. Perhaps you may find that you want to use parts of the 5th grade Atoms and Molecules unit again, as review. Check with the other teachers to see what they have done. If you won't be repeating too much, move full speed ahead.

An understanding of (1) what matter is composed of and (2) what interaction exists between substances - hence, a conceptual idea of atoms and molecules is a slow process which must be taken with small concrete steps. Remember, we cannot see atoms, yet we know a great deal about them. We know this by hitting them together, mixing, etc. and watching what happens. From this we infer their structure.

SCHEDULE:

Your involvement is with the children and not of handling materials any more than is absolutely necessary. The more you can promote student involvement in setting up - running - taking down the experiments, the greater the learning.

The unit is divided into 6 lessons which are designed to allow your children to observe, collect data, discuss and begin to intuitively understand the nature of matter. Each lesson will take 30-45 minutes to complete if you use a pre-laboratory discussion experimentation - post-laboratory discussion sequence. Leading questions are given throughout each lesson so that your children might be stimulated to do some additional experimentation. If you allow for the added discovery the unit or work will probably last the full three week request limit.

CAUTIONS:

You should caution your students that some of the chemicals they will use are POISONOUS and should not be put in their mouths. Have them handle everything as if it is poisonous and you should have no trouble. If they should spill some chemical on their hands they should go to the sink and wash it off with water. Newspapers on the student desks will be very helpful in controlling what spills there are.

BACKGROUND INFORMATION:

Now for some facts for you. These are included only as specific information to allow you to become more familiar with atoms and molecules. The information is not essential for the success of the unit!

PROPERTIES OF MATTER:

All materials have three characteristics: (1) They take up space (have volume), (2) they have weight, (3) they are all made up of atoms and molecules. All substances that have these three characteristics are called "matter". Wood, water, and air are all matter because they all take up space, have weight and are made of atoms and molecules. Because molecules have weight and volume, even though they are very small, matter also has weight and volume.

STATES OF MATTER:

Matter is found in three forms or states. These are solid, liquid and gas. A solid has a definite volume and shape of its own. A liquid has a definite volume but no shape of its own (it takes the shape of its container). A gas has no definite volume and no shape of its own. A liquid or a gas is often called a fluid, which is any material that flows.

MOLECULAR THEORY

This theory contains four main ideas: (1) all matter is made up of molecules. (2) There are spaces between molecules. (3) Molecules are always moving. (4) Molecules attract each other.

All matter is made of molecules and there are spaces between these molecules. The spaces between the molecules of a liquid are larger than the spaces between a solid. The spaces between the molecules of a gas are larger than those between the molecule of a liquid. It is hard to imagine spaces between the molecules of a solid, but if a piece of gold is put into a dish of mercury (silvery liquid), the mercury will go into the gold - the molecules of the mercury will slide in between the molecules of the gold.

Molecules are always moving. Each molecule in a solid vibrates around a fixed point. The molecules in liquids and gases move at random in all directions. The molecules in gases travel faster and farther than those in liquids.

Molecules attract each other. The force with which they do attract each other depends upon what kind of molecule they are, and also depends on how close they are to each other. The molecules attract each other much more strongly when they are close together than when they are far apart. So molecules in a gas are so far apart they hardly attract each other at all.

ATOMIC THEORY

This theory states that all molecules are made up of small particles called atoms, and atoms within a molecule attract each other very strongly.

The attraction between atoms in a molecule is much greater than that between molecules within a substance. For the attraction between atoms to be broken, a chemical reaction (accompanied with some form of energy) must occur.

SOLUTIONS AND SUSPENSIONS

A solution is a mixture of two or more materials evenly mixed together whose particles are separate molecules. Most solutions are made by dissolving a solid (solute) into a liquid (solvent), an example would be sugar in water. Some solutions are liquids in liquids (water in vinegar), gases in liquids (carbon dioxide in water or pop), and gases in gases (a mixture of oxygen nitrogen and carbon dioxide). Solutions have three characteristics: (1) The particles of the materials are separate molecules and cannot be seen even with a powerful microscope. (2) The particles in a solution are evenly spread through all parts of the solution and will never rise to the top or sink to the bottom. (3) The dissolved material cannot be removed by filtering the solution. The material doing the dissolving is called the solvent. The material being dissolved is called the solute. If a material will dissolve in another it is said to be soluble. If it is not able to be dissolved in the other material (oil in water) it is said to be insoluble. Salt is soluble in water, but insoluble in alcohol. Salt is the solute if water is the solvent.

The molecular theory explains what happens when materials form solutions. When any material is dissolved, it separates into its molecules. At first these are fairly close together because they attract each other. But the molecules of the solvent also attract them. All the molecules keep moving and bouncing about. The molecules of the dissolved material spread into the spaces between the molecules of the solvent. After awhile, all the molecules become evenly mixed and stay that way. In a solution such as sugar and water, the particles of sugar are separate molecules. The solution is clear because the molecules are much too small to be seen. They are also small enough to pass through a filter that the water molecules will go through.

Why some materials are insoluble in other materials can also be explained by the molecular theory. There is very little attraction between molecules of oil and water. When oil and water are mixed, the oil molecules tend to stay together and do not spread among the water molecules. By strongly shaking such a mixture, you can separate the oil into tiny clumps of oil molecules spread through the water. But after the mixture is allowed to stand awhile, the oil molecules will attract each other and come together and form a separate layer.

TEMPERATURE AND PRESSURE

Molecules are arranged differently in each state of matter. The molecules of a solid are very close together, and the attraction between is quite strong. They move about a fixed point because they are held so firmly. The molecules of a liquid are usually farther apart and the attraction between them is weaker. They move or slide around each other freely. The molecules of a gas are much farther apart and the attraction between them is very weak. They move or dart around and are scarcely held together.

When any material is heated, the molecules absorb the heat energy and start to move around faster than they normally did. If the material is heated enough, the molecules will be moving so hard and fast, that they will jerk away from each other and escape into the air (evaporation). As heat is added, the molecules move faster and farther apart and the material expands. If the material is cooled, the molecules slow down and move closer together and the material contracts.

The pressure a material exerts is due to the bombardment of the molecules on the side of the container that holds the material (for example air). If the air is heated, the molecules bounce around and hit the side of the container hard and more often, causing the pressure to increase on the inside of the container. If the air is cooled, the molecules slow down and hit the side of the container less often and the pressure is decreased.

Because there are large spaces between air molecules, air can be compressed or expanded fairly easily. If you put pressure on air inside an air-tight piston, the molecules will be pushed closer together and this will cause the pressure on the inside of the container to increase (more molecules hitting the side of the container). If the molecules are pulled apart, the pressure will decrease.

ELEMENTS AND COMPOUNDS

Every one of the many materials that we know about is different from every other material in one or more ways. Yet all these materials can be classified into three catagories: ELEMENTS, COMPOUNDS, MIXTURES. An element is a material that cannot be changed into simpler materials by chemical means. It is made up of only one kind of atom and if broken down into smaller units would only yield parts of atoms (nucleus, electrons, etc.). There are just over 100 different kinds of elements which also means there are just over 100 different kinds of atoms. Iron, copper, carbon, gold, hydrogen and oxygen are examples of elements.

Materials are made of molecules which in turn are made of atoms. An atom is the smallest particle of an element that can exist as that element. For example, an atom of iron is the smallest particle of iron that there can be. A molecule of an element is made of one or more atoms of the same kind. Most elements have only one atom in the molecule. Some of these are iron, copper, aluminum, silver and carbon. So in these elements the atom and the molecule are the same. But in some elements that are gases, the molecules contain two atoms of the same kind. There are two atoms of oxygen in every oxygen molecule. Other examples are hydrogen, chlorine and nitrogen. These molecules are called diatomic.

A compound is a material made of two or more elements joined together, or combined so they cannot be combined so they cannot be separated unless a chemical reaction occurs. One way to tell the difference between an element and compound is to see if the material can be separated into two or more different materials. Some ways this can be done is to heat the material, run an electrical current through the material, or add some other substance to the material and cause a chemical reaction. An example is as follows: Mercuric oxide is a compound of two elements, mercury (a silver-colored liquid) and oxygen (a colorless, odorless gas). When mercury and oxygen combine they form

a red powder which is mercuric oxide. When the red powder is heated, it breaks up into its elements, oxygen is given off and mercury is left. Mercuric oxide and table salt (sodium chloride - NaCl) are made of two elements. Water (H_2O), hydrochloric acid (HCl) and carbon dioxide (CO_2) are also made of only two kinds of elements. Sugar, alcohol and acetic acid are also made of only two kinds of elements. Sugar, alcohol and acetic acid are compounds that each have three different kinds of elements in the molecules. Alum, baking soda and some soaps have four elements in them. And there are some compounds that have even more elements than just four.

Materials that are not elements or compounds are called mixtures. The molecules in a mixture are intermingled, but they are not chemically combined. Each element keeps its individual property. For example, in a mixture of iron filings and sulfur powder you can see the individual particles of iron and sulfur. If you pass a magnet through the mixture the filings will drop to the bottom and the sulfur powder you can see the individual particles of iron and sulfur. If you pass a magnet through the mixture the filings will drop to the bottom and the sulfur will float to the top. The parts of this mixture can be separated by physical means. If this mixture were heated, a chemical reaction would occur and the two elements would combine and form a completely different substance - iron sulfide, which is a black material that is not magnetic and will not float on water (its properties have changed from the original materials). The molecule of iron sulfide (which is a compound now) contains one atom of iron and one atom of sulfur (FeS). Air is a mixture of gases, milk is a mixture of fats, water, and sugar and other materials, wood, paper, glass, and even your body is a mixture of a variety of elements and compounds.

PHYSICAL AND CHEMICAL CHANGES

A physical change is a change in which the material changes it size or form but remains the same material with the same properties. The molecules of the material are not changed, only the form, state or shape of the material has changed. For example, water goes through physical changes when it turns to ice or steam, but the molecules of water remain unchanged.

A chemical change is a change in which one material is changed into one or more different materials with different properties than the original material had. The molecules of the first material are changed by a chemical reaction into different molecules.

An example of a chemical change is the burning of sugar which contain carbon oxygen and hydrogen atoms in the molecule. When energy is added in the form of fire or heat, a chemical reaction occurs and the molecule is split, leaving carbon in the form of charcoal and water vapor is given off.

TEACHER BACKGROUND:

A crystal is a solid composed of atoms arranged in an orderly repetitive array. Consider, for example, the very widely known crystal calcite (Calcium Carbonate -($CaCO_3$). The pattern below (figure 1) shows the arrangement of calcium, carbon, and oxygen atoms in the calcite magnified about a hundred million times. Each "black" carbon atom is surrounded by three "white" oxygen atoms. As the calcium carbonate molecules arrange themselves (figure 2) the total macro structure appears as a rhombus.

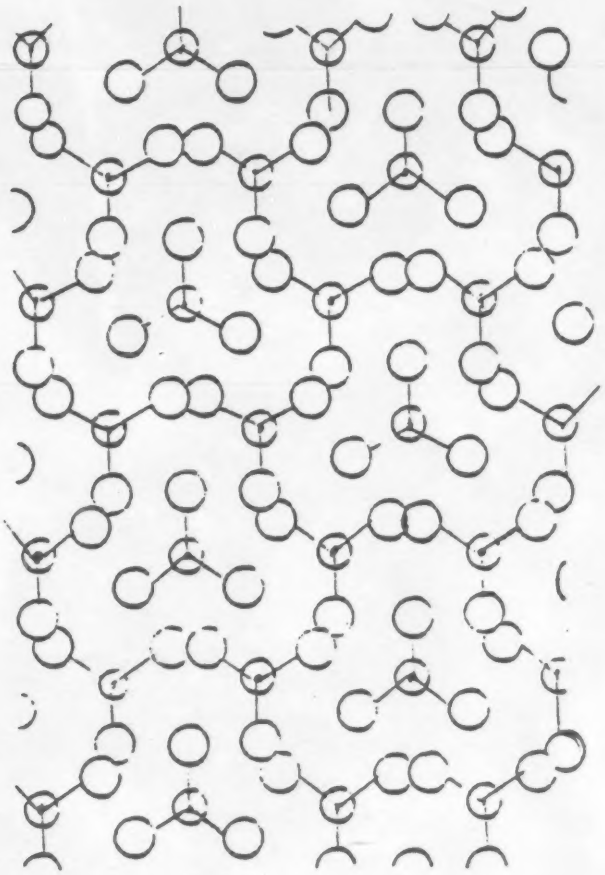


Fig. 1

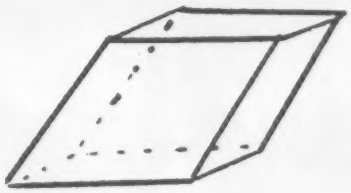
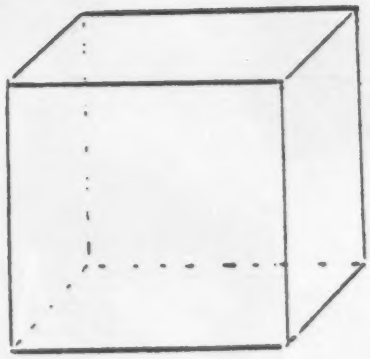


Fig. 2

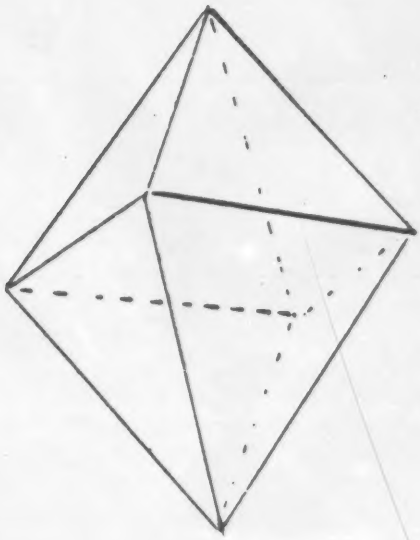
Many different kinds of crystalline macro structures can be observed by combining different atoms which characteristically form crystal foundations. This unit on "Atoms and Molecules" deals with several different chemicals to show of the properties of crystals and more important, to give children an opportunity to support a "mental model" of the structure of atoms and molecules.

DIFFERENT COMBINATIONS OF ATOMS TO FORM CRYSTALS:

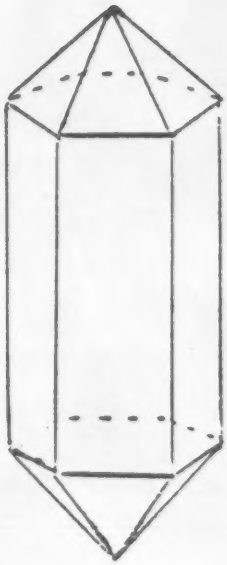
At first thought it may seem odd that, from approximately 100 elements, hundreds of thousands of different combinations can be formed. Combinations can only occur in certain ways. Chemical rules have been formed to account for the ways different atoms combine. Certain of these combinations form substance which we define as crystals (definite geometric forms which are distinctive).



SODIUM CHLORIDE



ALUM

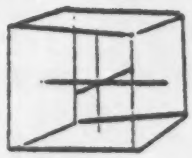


QUARTZ

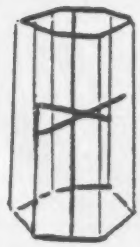
Fig. 3

CRYSTALS of a given substance are bounded by plane surfaces called FACES. The faces always intersect at an angle characteristic of the substance. For example, Sodium Chloride crystals (figure 3) form cubes with faces which intersect at angles of 90°.

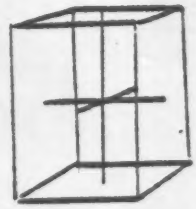
The existence of crystals can be accounted for by assuming that atoms, which make up a crystal, are arranged in orderly patterns. All crystal arrangements can be formed from six basic crystal systems (figure 4).



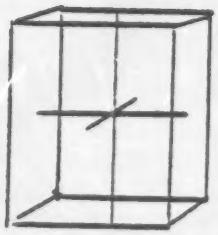
CUBIC



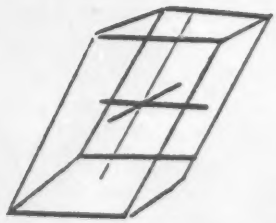
TETRAGONAL



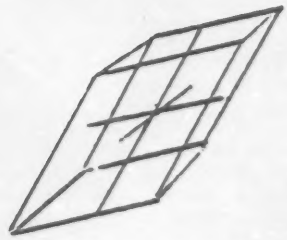
HEXAGONAL



ORTHORHOMBIC



MONOCLINIC



TRICLINIC

Fig. 4

LESSON I PILL BOXES

Concept: To identify an object by inference (a reasonable guess based on past experience).

Materials:

KIT	NON-KIT
35 pill boxes 35 objects	Paper and pencils

* Scientists are not able to see atoms and most molecules because they are too small, but they still are able to know how they look by the way they react with other materials.

* The "black box" method of inquiry is a good way for students to find out that even though they can't see many things, they can tell what they are like or, in some instances, what they are. The students do this by using their senses and relating what they sense to other things they know about.

* The entire atomic theory has been developed from inferences. The atom's structure is inferred from phenomena that can be observed very much in the same way that the identity of the hidden object (in this lesson) can be inferred.

* If you want a more formal lesson, you might consider drawing the following chart on the board for your students to follow:

QUESTION	MANIPULATION	OBSERVATION	ASSUMPTION

Procedure:

1. Before you begin this lesson, check to see if one object is in each pill box. There should be enough boxes so each student has one.

2. Pass out one box to each student. Caution the students not to open their box!

(Lead-off Question)

3. Ask, "Can you draw a picture of what is in the box?"

4. Indicate to your students that they can do anything they want to the box except (1) open it, (2) crush it, (3) dip it in water, etc.

5. Needless to say, the noise level in your room will rise for a time. Everyone will try to "shake it to pieces". LET THEM SHAKE! Soon the students will find they can't tell a thing when they shake the box vigorously. At this point suggest that they turn the box different ways.

6. The students may not know what the object is, but they can probably draw a pretty good picture of the object. Have them draw what they think the object looks like.

(Follow-up Question)

7. After they have drawn their pictures ask:

"What pictures did you draw?"
"How many of you drew the same thing?"
"Can anyone describe the object?"
"What other things might you do to know what the object looks like?" - "Without looking at it?"
"Do you have to see every object to know what it looks like?"

8. This is a fun lesson and can be extended to any hidden objects in the pill box or a larger box. Perhaps your students will want to try some other materials. Practice in inferring is a valuable exercise.

9. Some properties you might try to stress are: (1) size, (2) hardness, (3) shape, (4) material composition, e.g., like metal, like glass, like rubber, like rock, etc.

LESSON II BURNING CANDLES

Concept: To differentiate between an observation and an interpretation.

Materials:

KIT	NON-KIT
5 candles Matches	Paper and pencil

* Scientists are able to learn a great deal about chemical and physical systems as long as they are careful to observe reactions within the systems. It is important, as your students observe the burning candle, that they list only those things they observe.

* You will find your students mix interpretation with observations. This lesson will give you a chance to focus on the importance of being specific about the thing seen, then making interpretations based on the observations.

* In order for all students to be near the burning candle, place several throughout the room.

Procedure:

1. Set (stick) several candles around the classroom. Light each without comment. Your students will need pencil and paper.

(Lead-off Question)

2. When each candle is burning ask your students to list as many observations as they can about the burning candles. (There are probably about 75 observations you can make for the burning candles — you might try it too).

* Observations include:

   a. The flame is yellow
   b. The flame has three parts
   c. The candle is white
   d. The flame burns from a string-like wick

* If you were to say: "The candle is made of wax", this is an interpretation, not an observation! You and your students will probably mix them at first - however, this is the fun of the game!

(Follow-up)

3. You might want to expand on the candle experiment. Any action-type phenomena can be used, e.g., opening and closing the classroom door; dropping a piece of chalk; boiling water, etc.

4. Another possible extension is the problem shown on page 10 (Milk Bottle Quiz).

* Statement number 9 is an observation. All of the others are interpretations.

MILK BOTTLE QUIZ

The milkman delivered two bottles of milk, which were left on the doorstep overnight. In the morning you see that the bottles are cracked and that the bottle caps are on top of columns of solid milk.

Consider each statement below and indicate whether it is an OBSERVATION or an INTERPRETATION.

_____ 1. The same thing would have happened if water had been in the bottles.

_____ 2. Milk contains a lot of water.

_____ 3. The milk was changed from a liquid to a solid.

_____ 4. The caps were pushed up by the milk.

_____ 5. The bottles cracked when the milk expanded.

_____ 6. Milk expands when it freezes.

_____ 7. The temperature dropped below the freezing point during the night.

_____ 8. The milk expanded.

_____ 9. The milk was solid when you found the bottles.

_____ 10. It was winter.

LESSON III BLACK AND BLUE AND BUBBLES

Concept: To be able to identify unknown substances by comparing observations of chemical and physical changes in reactions.

To construct a record of observed changes.

Materials:

KIT	NON-KIT
125 vials	Paper and pencil
35 plastic containers	
1 package splints	
55 medicine droppers	
1 box cornstarch	
1 box talc	
1 box baking soda	
1 box baking powder	
1 quart white vinegar	
1 bottle iodine	

* Many properties of a material are unchanged in reactions. For example color, odor, taste, behavior in water, reaction to heat, etc. are unchanging characteristics. These characteristics can be used to identify what the unknown is. The basis of this lesson is this predictable behavior of (chemical) substances.

* One requirement for success in this, and the next few lessons, is to keep the materials free of contamination. If the powders and liquids become accidently mixed the results will be meaningless.

* Newspapers on the student tables are helpful.

Procedure:

1. Divide your class into teams of two. Have each obtain 7 vials and fill each with a different material (you may want to place half of the chemicals in the front and half in the back of the room to prevent congestion). Each team should also have several clean sticks, medicine droppers and containers.

2. Each team should have a vial with each of the following chemicals:

   a. Cornstarch
   b. Talc
   c. Baking soda
   d. White vinegar
   e. Baking powder
   f. Water
   g. Iodine solution (take care, iodine is poisonous and will stain clothes) - To make the iodine solution, add 10 ml of iodine to 500 ml water in order to make a light-orange color.

*One type of data sheet is shown below - Possible answers are for your information!

Powder \ Liquid	Water	Iodine Solution	Vinegar
Baking Soda	No bubbles Solid Dissolves	No Bubbles Solid dissoves	Many bubbles Solid dissolves
Cornstarch	Bubbles Cloudy liquid Solid settles	Bubbles Cloudy liquid Solid settles Material turns blue-black	Bubbles Cloudy liquid Solid settles
Talc	No bubbles Cloudy liquid Solid settles	No bubbles Cloudy liquid Solid settles	No bubbles Cloudy liquid Solid settles

(Discussion) 10. After the students have completed their "experiments" have them compare their observations. If disagreements arise, the experiment can be repeated. (Scientists often repeat their test procedures so they can be sure of their results).

LESSON IV FLOW CHART ANALYSIS

Concept: To identify unknown substances by comparing observations of chemical and physical reaction.

To use a flow chart in analyzing an unknown substance.

Materials:

KIT	NON-KIT
17 vials	Paper and pencil
35 plastic containers	
1 package splints	
55 medicine droppers	
1 box cornstarch	
1 box talc	
1 box baking soda	
1 box baking powder	
1 qt. white vinegar	
1 bottle iodine	

* The model flow chart shown in this lesson can be used to identify one or more of the substances the students worked with in the last lesson. It appears somewhat complicated, but is nothing more than a drawing showing the different elimination steps necessary to identify an unknown. Read the chart from top to bottom. Each time the word unknown is shown, the students should start with the original material.

* As an introduction to this lesson, and the flow chart, you might review the previous lesson with questions such as the following:

1. "Can you name all the powders that form bubbles when water is added?"

2. "When iodine is added to baking powder, what will happen?"

3. "Which substances turn blue-black when iodine solution is added?"

4. "How would you describe cornstarch?"

Etc.

Procedure:

(Lead-off Question)

1. Suppose you are given one of four white powders but are not told its name. "If you add a few drops of iodine and the powder did not turn blue-black, can you be certain whether or not this powder contains cornstarch?" (Yes)

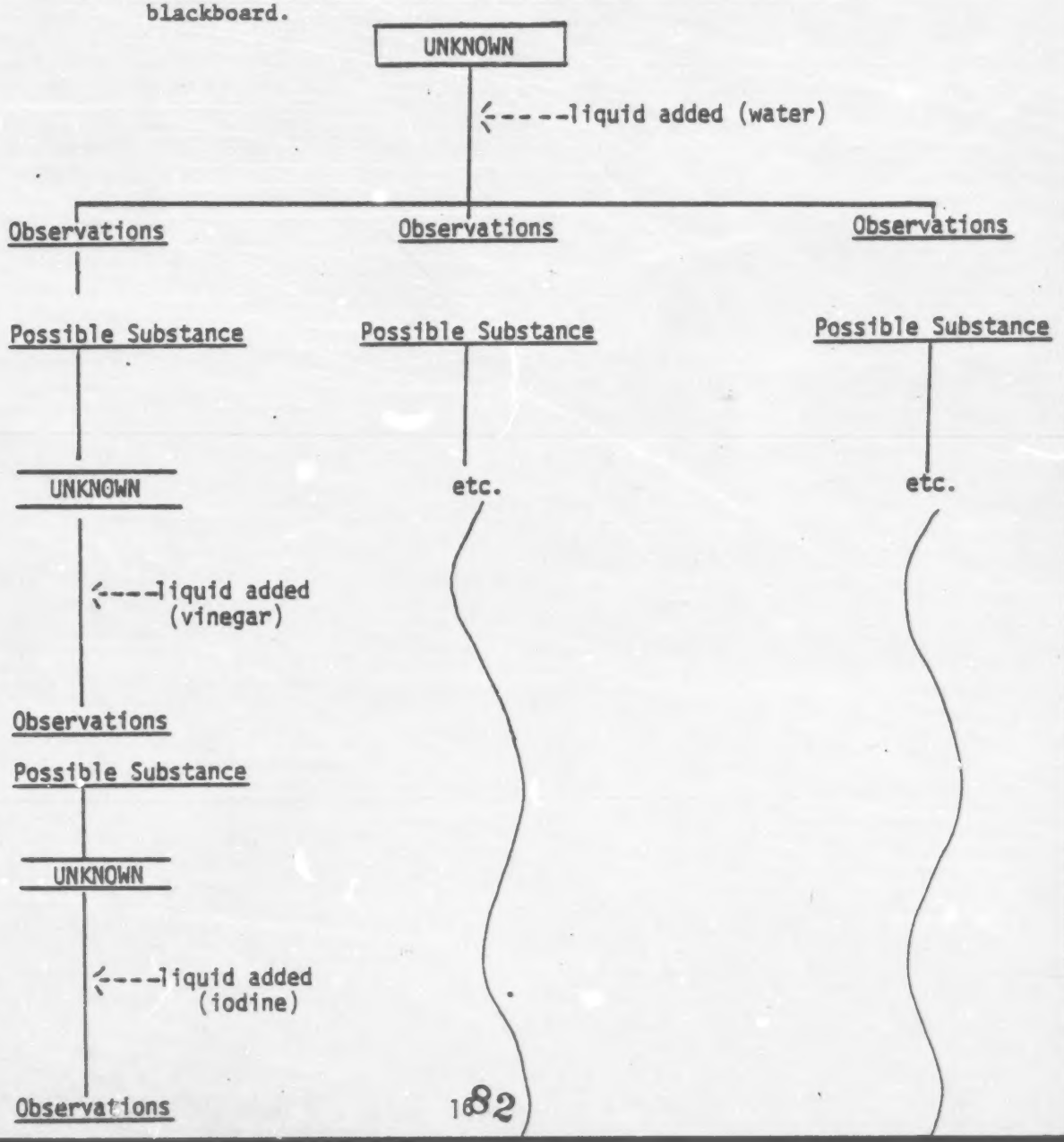
LESSON IV FLOW CHART ANALYSIS (continued)

2. "Can you be certain that the unknown contains talc?" (No) "Why not?" (could be baking soda)

3. Continue this type of questioning until the students are fairly adept at using the information.

4. Divide your class into teams of two. Give each team one of four vials labeled A, B, C, D, each containing one of four powders. You will need to make these up the day before the lesson.

5. Next, iescribe the flow chart as shown. Put outline on blackboard.

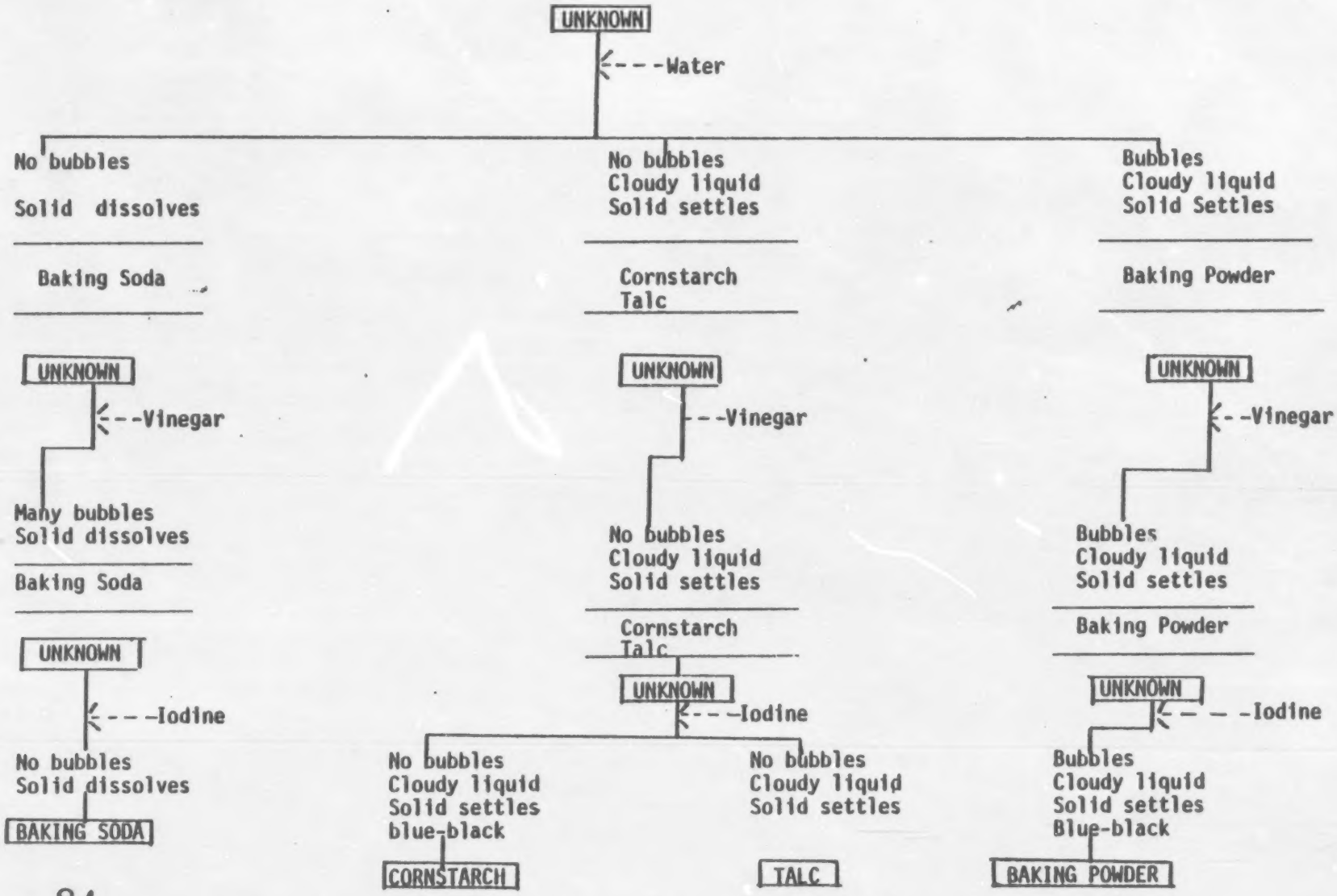


LESSON IV FLOW CHART ANALYSIS (continued)

6. Have the students experiment to identify the unknown powder. When they think they have it tell them to write the letter and name of a piece of paper and describe the results of their tests.

7. Students can then continue on to the other unknowns.

FLOW CHART



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LESSON V COMPLICATED MIXTURES

Concepts: To identify the unknown components of mixtures by comparing chemical and physical properties of substances.

To demonstrate a procedure for separating mixtures.

Materials:

KIT	NON-KIT
17 vials	Paper and pencil
1 box talc	
1 box baking soda	
17 10 ml graduated cylinders	
1 qt. vinegar	
1 qt. iodine	

* Before class, prepare a mixture of equal parts of baking soda and talc. Make enough to fill a vial for each of the teams of two.

* Before beginning this lesson you may want to review, with the students, the last two lessons. You might ask the students to recall what they did in the last experiment.

Ask, "What materials did you test?" (Baking soda, baking powder, cornstarch, talc)

"Does this powder (pass out vials or show) resemble any of the materials you used before?" (Yes)

"If the powder were one of the powders you used in the last experiment, would you be able to identify it?" (Yes - use water, iodine solution, vinegar)

"If the powder were a mixture of the powders you used in the last experiment, would you be able to identify what materials were in it?" (Some students will say yes, others no - this is a difficult question and should allow you to move into this lesson - "Let's find out")

Procedure:

1. Divide your class into teams of two. Give each team a vial with the mixture in it.

2. Tell the students that you would like them to determine if there is a mixture of the powders they have worked with previously, in the vials. And, if so, which ones they are.

3. The students should plan which tests they are going to run and what records they need to keep. When they have a procedure, allow them to proceed.

* One possible plan is:

1. Place three small portions of the "unknown" into three containers. Add one of the solutions to one portion, a second to another portion, etc. Results will be similar to experiment IV.

* These tests indicate the absence of two of the four materials and the presence of one. Therefore, only two possibilities remain; either the material is baking soda, or it is a mixture of baking soda and talc.

(Follow-up Question)

4. As each group comes to the conclusion that it may be a mixture of baking soda and talc suggest the following:

"Add some of the unknown to approximately 15 milliliters of water and shake. If the water remains cloudy it indicates the presence of a substance which will not dissolve in water".

Ask, "What does this prove?" (Baking soda dissolves in water and talc does not; therefore, the unknown contains both).

(Discussion)

5. The plans from the different teams may vary somewhat; however, the final conclusion should be the same. Some students may have been able to reach only the intermediate conclusion that the unknown contained baking soda or a mixture of baking soda and talc. You might want to demonstrate the last step for the class.

LESSON VI DIAMONDS AND OTHER THINGS

Concept: To observe the unique arrangement of atoms and molecules in crystals.

To observe the dissolving and recovery of solids.

Materials:

KIT	NON-KIT
Copper sulfate	Water
Rochelle salt	Jars for growing crystals
Alum	
Chrome Alum	
Sodium carbonate	
Magnesium sulfate (Epsom Salts)	
Salt	
Sugar	
Cream of Tartar	
Iodine stain	
Anhydrous copper sulfate	
10 Petri dishes	
20 Microscope slides	
Hot plate - if available	
10 Beakers	
5 Steroscopes	
18 hand lenses	

* The series of lessons beginning with this lesson will be of high interest to your students. This is because of the seeming magic of growing crystals.

* Crystals are grown from saturated solutions. A saturated solution is one that has as much solute in it that can be dissolved in the solvent at a given temperature. For example, 100 ml of water (solvent) is 15C will hold 40 gms of table salt (solute). If the temperature is raised, more salt can be added. A solution is saturated when there is no more room between the solvent molecules for the solute (salt) molecules.

* If a saturated solution is allowed to sit opened or the temperature is reduced, the material will settle out as crystals.

* Stereoscopes are used in this series of lessons as well as hand lens. It will be necessary to have the teams rotate in using the stereoscopes. The scopes are very easy to use. Place the stereoscope cords over the back of a table on different walls of your room. This will prevent students "catching" the cords with their feet.

Procedure:

1. Have your students work in teams of two. Place the kit chemicals in the front and back of the room so any one area is not overcrowded.

2. Have student teams make up saturated solutions according to the following directions. Remember that the amounts shown are only approximate.

NAME	AMOUNT	OPERATION
Copper Sulfate	1 plastic container	Add 3 Tbsp. and stir
Washing soda (sodium carbonate)	or baby food jar	" 5 " " "
Epsom salts (magnesium sulfate)	"	" 10 " " "
Sugar (sucrose)	"	" 10 " " "
Alum	"	" 5 " " "
Salt (sodium chloride)	"	" 3 " " "
Cream of Tartar	"	" 2 " " "
Rochelle Salt	"	" 8 " " "

* Us boiling water when making these solutions!

Procedure:

3. Boil a large pot of water.

4. Pour boiling water into small baby food jars. Hold them with a cloth to keep from getting burned.

5. Add the following chemicals in the approximate amounts and stir and stir until the chemical no longer dissolves. Give it time.

6. Let the undissolved chemicals settle while the jar is still hot, decant the liquid into another jar, leaving the undissolved chemicals behind.

7. Let the jars settle overnight. Cover lightly to allow evaporation yet prevent dust from falling in it. Partly cover the epsom salts with paper as it crystalizes very fast.

8. The next day you should see "seed" crystals forming in the bottom.

9. Carefully decant off the liquid into a clean jar, leaving the seed crystals in the first jar.

10. With a probe, pencil, or stick, carefully break out the seed crystals onto a piece of paper. Pick the best one.

11. Take a piece of thread 18 inches long. Make a loop and pull it around the crystal. Tie it carefully and cut off the excess thread. You should be left with the crystal dangling on the end of the rest of the thread.

12. Suspend the seed crystal from a pencil into the middle of the freshly decanted liquid.

13. Allow the crystal to grow.

14. If any other crystals appear anywhere except on the seed, decant the liquid once more and suspend the seed once more into the middle of the newly decanted liquid again.

    A challenge can be made to the students to see who can grow the largest and clearest crystal.

15. Once the solutions have been made, each should be marked and covered.

16. Since the remaining exercises are student directed (worksheets) a general overview is shown here for you.

LESSON SUMMARIES:

Worksheet 1: Introduces the students to the techniques and procedures they will follow in the study of crystals. Try to have each pair of students use the microscopes a little while so that all of the class becomes familiar with its use.

Worksheet 2: Is long and requires careful work. You will find no lack of interest on the part of the students. They will move about the room obtaining various materials. There will be a buzz in the room--there should be.

In the first part of Worksheet 2 the student examines the appearance of various substances under the microscope before dissolving them. They are asked to draw pictures of what each substance looks like. In this activity some will begin to develop the ability to draw while they simultaneously look through the microscope. This is not easy, so encourage this drawing while looking through the scope, but do not require it.

In the second part of Worksheet 2 the children will examine solutions of substances viewed in the first part. They will observe droplets placed on a microscope slide and not interesting characteristics of the crystals that appear in the water as the solution evaporates. There are a series of seven questions which must be answered for each solution. Methods of recording these answers will vary. Encourage the development of organized plans for recording information.

Another interesting solution to observe is made from a pinch of Salol in alcohol. Portions are not critical, the crystals grow rapidly, beautifully forming their unique shapes.

Worksheet 3: Worksheet 2 showed that crystals will grow from a solution of their own substance. In Worksheet 3 the students are trying to find out if crystals will grow from a solution of different substances. The answer is "No". A crystal of any one of these substances will dissolve in a solution of a different substance even while that different substance is growing.

Worksheet 4: In this lesson we obtain further evidence about the unique nature of crystal growth.

The first question deals with the growth of crystals from any solution of its own substance. Crystals will not grow from any solution of its own substance. A crystal growing in a drop of solution will begin to dissolve again if a drop of water is added to the drop of solution under the microscope. The crystals will again start to grow when this added drop of water has evaporated. When there is no longer any suitable material for a crystal to grow from and it has consequently stopped growing, the crystal does not lose its capacity to grow. A dry salt crystal, for example, put into a drop of solution which is growing salt crystals will grow along with the other crystals. The dry crystal will only dominate. A crystal never loses its ability to grow. At any time, given the correct conditions, a crystal of a particular substance is always prepared to grow.

Worksheet 5: As crystals grow, their corners are sharp; as crystals dissolve, their shape has rounded corners. A crystal grows from its outside. Careful observation of salt, for instance, makes this quite apparent. The little cube of salt may include within itself a cube outline which remains while the crystal grows.

Chrome alum and ammonium alum are closely related substances. It is possible to grow a drop's worth of chrome alum crystals, then add a drop of ammonium alum solution and have crystals continue to grow from the new substance. Very few things will behave this way. If you start with chorme alum and get the crystals thick enough, you can even see their purple color. Then when you continue growth with the colorless alum, the demarcation line shows as a change in the color.

In each case you can observe that the crystal grows only at its surface; the inside does not change. Hence, if a crystal has a cell wall the material that penetrates it must be growing no farther than just above the wall. It can be asked that since a crystal has a natural shape has it also, like a cell, a natural size? No.

With patience, luck, etc., one can grow any crystal bigger and bigger while supplying enough of its substance. Hence, if the crystal has a cell wall, the cell wall must be able to expand as the crystal grows. These observations have not truly answered the question as to whether the cell has a cell wall but it has shown that if there is such a wall it has very peculiar properties. It is usually assumed that there is no crystal wall. It is hard to be certain from microscopic observation about whether a crystal has a nucleus like an organic cell. Many crystals appear to have a nucleus but many others are entirely clear and transparent. As crystals grow, they often develop little flaws that suggest the appearance of nuclei as growth continues; for example, that which you noted in the salt. Further, most crystals are enough thicker in the middle for the light to appear to have some difference in its quality there. The refraction will be slightly different than the middle. We can say that it does not seem necessary that a crystal has a nucleus, however.

Worksheet 6: It is very easy to observe that crystals stop growing where they bump into each other. A crystal needs substance to grow from. Where there is no substance, such as the points where the crystals come in contact, the crystal stops growing. As the solution continues to evaporate, the crystals may become a densely packed solid mass and the individual crystals, earlier observed to grow with their characteristic shape, will end with those shapes distorted. The final shape of each will depend on how all of the growing crystals grew in contact with one another.

Some crystals contain water and can be dehydrated (usually by heating, but sometimes by sealing them in a container with a water absorbant such as calcium chloride).

When the water is removed from a crystal (dehydrated) the substance is not destroyed. The crystals crumble into finer dust when the water is removed. These finer particles, when viewed under the microscope, reveal different shapes from the original crystals. If some of the dry particles are dissolved in water, crystals similar to the original ones will be formed as the water evaporates. You will see that the children will certainly enjoy this particular phenomenon.

WORKSHEET #1

NAME _____

_____

1 Place some salt in a petri dish and look at it. What does the salt look like? _____.

_____

2. Draw a picture of what you see.

3. Do the same for sugar. What does it look like? _____

_____

4. Draw a picture of what you see.

When any of these substances is dissolved in water the solid material disappears but surely the substance has not been destroyed, for water which has dissolved sugar, tastes sweet and water which has dissolved salt tastes salty. Perhaps evaporating the water away might restore the solid substance. Allow a drop of salt solution to evaporate on a microscope slide. Place the drop on the slide with a toothpick. Observe the drop through the microscope as it slowly evaporates.

5. Describe what you see. _____

_____

6. Do the same thing for your sugar solution and describe what you see as it slowly evaporates. _____

_____ _____

WORKSHEET #2

NAME _____

_____

On Worksheet 1 you saw grains reappear out of the liquid as the drop evaporated. These grains were crystals; crystals of salt, crystals of sugar. We can observe many different crystals as they grow, answering many interesting questions. Let us find out something about the following substances--washing soda, Epsom salts, alum, copper sulfate, salt, cream of tartar, Rochelle salt, sugar and potassium iodide. Study each of these substances under the microscope before dissolving them. Write down or draw a picture of what each one looks like.

Washing Soda

Emsom Salts

Alum

Copper Sulfate

Salt

Cream of Tartar

Rochelle Salt

Sugar

Solutions of each of these substances have already been made. Put a drop of one solution (using a toothpick) on a microscope slide and observe the drop through a microscope as it slowly evaporates. For each solution, answer the following questions:

1. Are crystals visible immediately?
2. In half a minute?
3. How fast do the crystals grow once they begin?
4. How big do they get?
5. Where do the crystals begin to grow in the drop?
6. What can you say about their shapes? Compare them with shapes you saw before they were dissolved.

WASHING SODA

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

EPSOM SALTS

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

ALUM

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

COPPER SULFATE

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

SALT

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

CREAM OF TARTAR

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

ROCHELLE SALT

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

SUGAR

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

WORKSHEET #3

NAME _____

_____

You have seen many different crystals grow. Do you think the growth of crystals is like the growth of living things? The following suggestions may help you answer this question:

What kind of substances will these crystals grow on? We have already seen them grow from a solution of their own substance but will they grow from a solution of a different substance? We can find out. Let a drop of salt solution evaporate to dryness on a microscope slide. After examining the dry crystals that have been deposited, put on these dry crystals a drop of washing soda solution.

1. What happens to the salt crystals? _____

_____

2. Do new crystals start to grow? _____

Do this experiment again with alum and Epsom salts. Place a drop of Epsom salt solution on dry crystals of alum.

3. What happens to the alum crystals? _____

_____

4. Do new crystals start to grow? _____

5. Are these new crystals alum crystals or Epsom salts crystals?

_____

6. Now you can answer our original question. Will crystals of one substance grow from the solution of another substance? _____

WORKSHEET #4

NAME _____

_____

We learned on Worksheet 3 that crystals of any one substance will dissolve in a solution of a different substance even while that different substance is growing. Do you think crystals will grow from any solution of its own substance? Find out by adding a drop of water to a drop of solution you are watching grow under the microscope.

1. What did you discover? _____

_____

_____

_____

When there no longer is any material for crystals to grow from and they have consequently stopped growing, do crystals lose their ability to grow any more--today--tomorrow--next year? Let's find out. Place a drop of salt solution on a microscope slide and watch the crystals grow as you look at them through the microscope. Drop into this solution a few crystals of salt.

2. Do these crystals grow or do they disappear? _____

3. Do crystals ever lose their ability to grow? _____

WORKSHEET #5

NAME _____

_____

Crystals never lose their ability to grow. Dry crystals remain dormant. They will always grow more when they are placed in a solution which is growing similar crystals.

1. Are crystals like living cells? _____

2. Do living cells ever lose their ability to grow? _____

You have seen crystals growing and dissolving. What is different about the shapes of growing crystals and dissolving crystals? _____

_____

3. How does the shape of growing crystals compare with that of dissolving crystals? _____

_____

How does a crystal grow? Does it have a cell wall like a living cell? We can do an experiment to find out how a crystal grows. Chrome alum and ammonium alum are closely related substances. Chrome alum crystals have a purple color and ammonium alum crystals are colorless. Grow a drop's worth of chrome alum crystals, then add a drop of ammonium alum crystals and observe the crystals continuing to grow.

4. Does a crystal grow by adding material to its outside _____ or to its inside _____?

Check your decision by making a careful observation of salt crystals growing from a salt solution. All crystals grow only at their surface; the inside stays put.

5. How do living cells grow? _____

6. Is the surface of a crystal like that of a cell? _____

7. Does a crystal have a crystal wall? _____

8. Do crystals have nuclei or something that looks like them? _____

WORKSHEET #6

NAME _____

_____

As crystals are growing from a solution, what happens when they bump into each other? At points where growing crystals bump into each other there is no material from which crystals can grow. Crystals stop growing when they bump into each other. Observe some crystals growing to check this. Note the shape of the crystals as they just begin to grow. Compare this with the shape of crystals after many have come in contact with each other.

The reversibility on growth of crystals can be demonstrated with iodine stain. Place a drop of iodine stain on a microscope slide and put it aside for about ten minutes to allow to dry. What do the dry iodine crystals look like under the microscope? _____ While you are looking through the microscope, get someone to breathe gently toward the slide. You will see the crystals dissolve in the mist droplets from the breath. If you are patient for a moment, this moisture will evaporate and you will have crystals again. Do this again and again. Crystals will grow and dissolve as often as you wish.

We know that much of the material in living cells (organic cells) is water. As you know, most of the crystals you have observed grew from a solution made of water and the substance. Therefore we could ask the question, "When crystals grow from water solution, do these crystals contain water as cells do?"

To find out:

Put a small amount of anhydrous copper sulfate on a microscope slide and examine it closely.
What color is it? _____
What color is copper sulfate (Lesson 2)? _____
Are the particles the same, or different, in shape from the copper sulfate crystals you saw in Lesson 2? _____
With a toothpick, add a drop or two of water to the powder. What color do you see now? _____
Watch for crystals to form as the drop evaporates. Are these copper sulfate crystals? _____
Do you think that copper sulfate crystals contain water? _____
Why do you think so? _____
_____
Explain what anhydrous copper sulfate is _____
_____
How do you think the anhydrous copper sulfate was made? _____
_____

100

OPTIONAL LESSON 7

Growing Large Crystals

In the previous lessons you have learned a great deal about how crystals grow. You saw how crystals grow from commonplace chemical solutions. These crystals are made of many small units which we call atoms. These atoms are the "building blocks" of matter. It is amazing to watch how a crystal grows, adding building blocks (atoms) to its surface in a unique and orderly manner. You can grow large crystals in a jar. Not all of your attempts will meet with success, however.

One nice thing about this particular project is that you can set the jars in the corner of the room or at home in your bedroom and you can just leave them there. The crystals will grow by themselves; you don't have to help them a great deal. Perhaps it would be favorable if you would try to grow crystals for five or six weeks.

In this method (growing by evaporation) you start with a saturated solution and permit it to slowly evaporate. The jar is not sealed but the top is covered with a piece of cloth, e.g., cheesecloth. The cloth top reduces the rate of evaporation and keeps dust out of the solution. The crystals grow as the water evaporates.

Alum is an excellent choice for this experiment. Copper sulfate also does well, but is poisonous. Common table salt usually does well.

To make the saturated solution, heat some water to almost boiling and add alum, (stirring vigorously) until no more will dissolve. Allow it to cool to room temperature. Pour the liquid part into a quart jar - it is the saturated alum solution. Seal it until you're ready to start the crystal growing.

In order to grow crystals, it is necessary to start with a seed. The seed should be approximately 1/8 to 1/2 inch long so that you can tie a thread to it. It must be single so a crystal grown from it will also be single. The seeds can be obtained by placing an ounce of your saturated solution in a glass and setting it in an undisturbed place. A few crystals will grow in the bottom as the solution evaporates. It may be necessary to add a very small amount of alum to this sample in order to obtain some crystals. Observe this small sample once or twice a day and harvest your seeds, using, perhaps, tweezers before they grow enough to touch and interfere with each other. Dry them well on some Kleenex. Collect several seeds; you may need them.

Tie the thread to the seed crystal and hang it from a pencil across the mouth of the jar, so that the seed crystal hangs about an inch above the bottom of the jar. Cover the top with a piece of cloth and set the jar where it will be undisturbed for a few weeks. Don't set it in sunlight or a draft, since the solution will evaporate too fast and the crystal will be small. Crystals that form on the bottom of the jar can be overlooked, so long as they don't interfere with the growth of your crystal.

TEACHER'S RESOURCE BOOK

FOR

BATTERIES AND BULBS II

GRADE 6

September 1978

Superintendent of Schools
Anchorage School District
4600 DeBarr Road, Anchorage, Alaska 99504
Telephone (907) 333-9561, Extension 231

A Program Development Division Production

BATTERIES AND BULBS II
(Supplemental Unit)

Grade 6

This unit consists of a manual and tools for students to "invent" or build their own electrical equipment.

Students should have done some work with Batteries and Bulbs I.

A reprint of the burglar alarm challenge has been included.

Scheduling: Allow small groups of students to work independently and informally. Students should have the opportunity to work in their own way at their own pace. Each group should have access to the Batteries and Bulbs II Resource Book. The descriptions are intended to be used as a source of ideas rather than models to be copied.

Read the note to teachers pp. 1-3 before giving the materials to the students. Glance also at the Appendix which gives possible sources of items, and list of books, pp. 129-134.

Students will need a variety of scrap lumber which can be obtained from local lumber yards or from construction sites. Saws, hammers, and nails are high priority items.

THE BURGLAR ALARM CHALLENGE

PURPOSE: To construct various burglar alarms. To understand how each system functions.

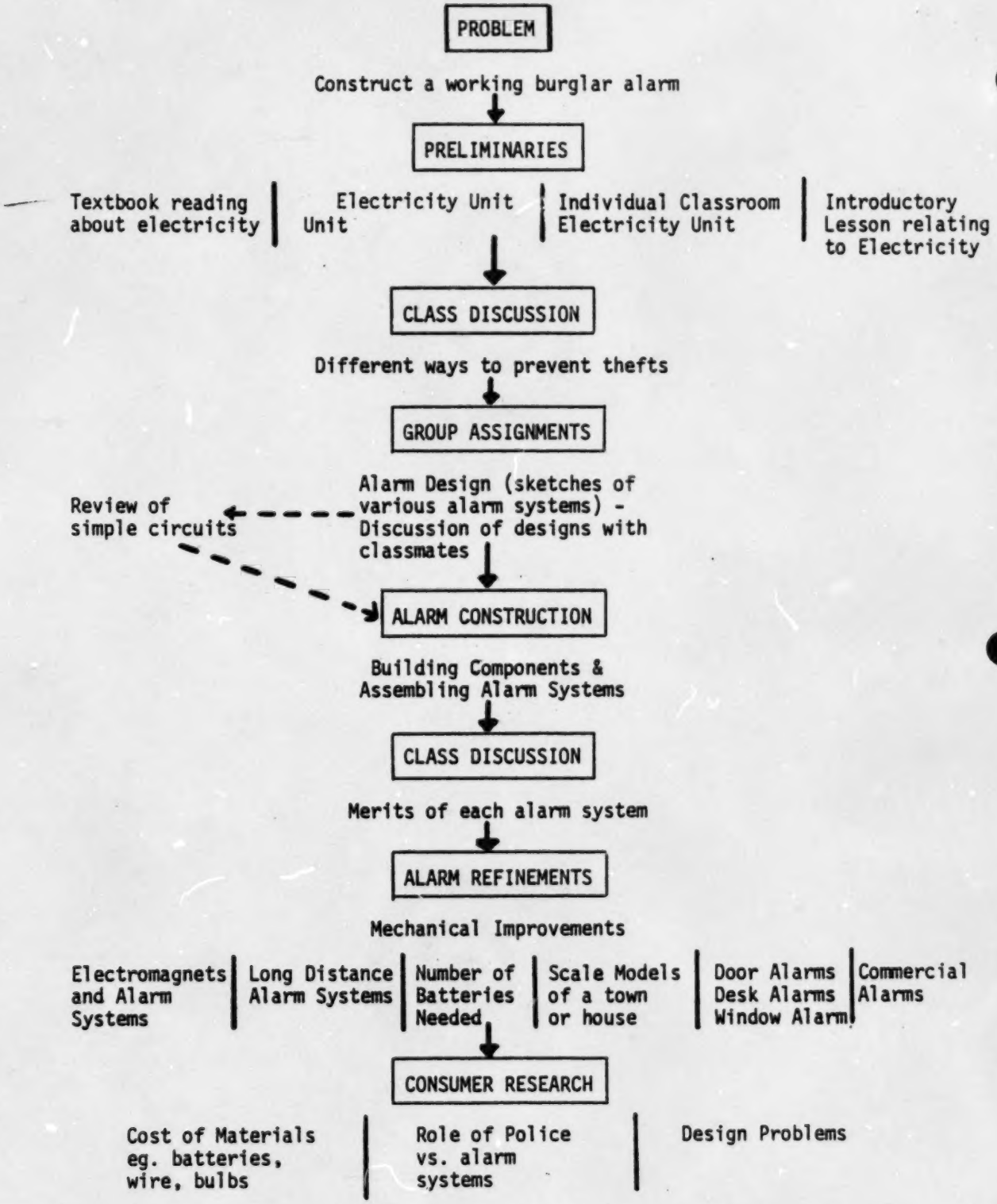
BACKGROUND: Now that you have been using the electricity unit, perhaps you would like to extend the activities to some "real life" situations. One such problem, you might consider, is the, "Burglar Alarm Problem", described below. Other problems are of the gadget-making variety, such as circuit boards, buzzers, electric crane, motor, electromagnet, etc.

To be successful your students will need to know:

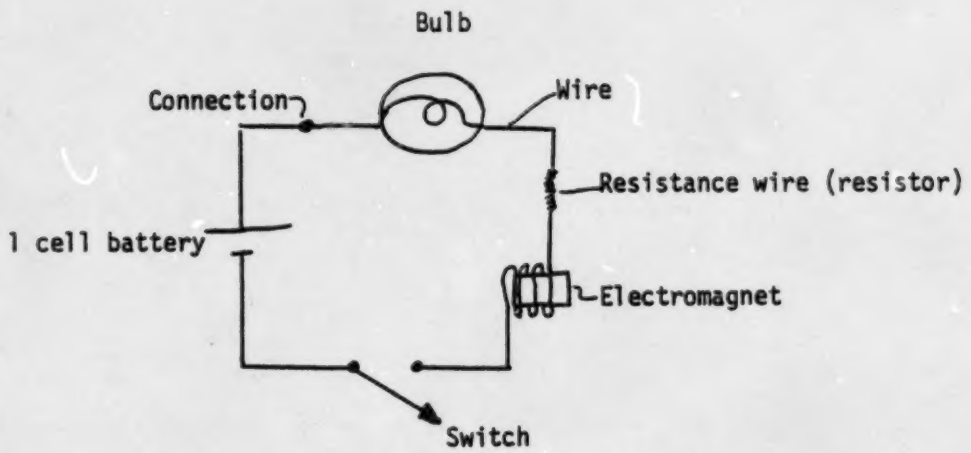
1. How to complete a circuit
2. What are good conductors and insulators
3. How a switch works
4. How to draw a schematic drawing

The degree to which they understand each of these points will vary with their ingenuity in experimenting. Perhaps the best thing is to excite them with the problem and then, "get out of the way."

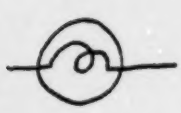
The unit of work deals with the technology of electricity. It approaches the topic of burglar alarms through a group approach. The term, "group" can mean different things to different people. To one teacher it means everyone doing the same experiment, working in groups. To another teacher it means groups of students doing different and often unrelated experiments. The later pattern is promoted in this unit of work. A schematic, of how the various parts of this unit might fit together is shown below.


PROBLEM
Construct a working burglar alarm
PRELIMINARIES
Textbook reading about electricity
Electricity Unit
Individual Classroom Electricity Unit
Introductory Lesson relating to Electricity
CLASS DISCUSSION
Different ways to prevent thefts
GROUP ASSIGNMENTS
Alarm Design (sketches of various alarm systems) - Discussion of designs with classmates
Review of simple circuits
ALARM CONSTRUCTION
Building Components & Assembling Alarm Systems
CLASS DISCUSSION
Merits of each alarm system
ALARM REFINEMENTS
Mechanical Improvements
Electromagnets and Alarm Systems
Long Distance Alarm Systems
Number of Batteries Needed
Scale Models of a town or house
Door Alarms
Desk Alarms
Window Alarm
Commercial Alarms
CONSUMER RESEARCH
Cost of Materials eg. batteries, wire, bulbs
Role of Police vs. alarm systems
Design Problems

ELECTRICAL DIAGRAM & SYMBOLS



(OTHER SYMBOLS)



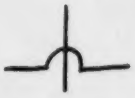
Bulb

Blinking bulb

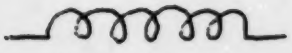
Antenna

Ground

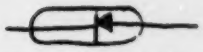
Connected Wire



Non-Connected Wire



Coil



Crystal Diode

Microphone

3 cell battery

Transistor (PNP)

GLOSSARY
Burglar Alarm Unit

You may find the following glossary useful during the Burglar Alarm Unit. It is not necessary for your students to learn these terms. However, you may talk about these terms as the unit develops.

CURRENT - The movement of electrons (negatively charge electrical particles)

ALTERNATING CURRENT (A.C.) - Electric current which moves first in one direction, them the other direction. Household current is generally A.C. The flow, back and forth, takes place at the rate of 60 times per second.

DIRECT CURRENT (D.C.) - Electricity which moves only in one direction.

CONDUCTOR - A material which allows electric current to flow through it.

INSULATOR - A material which does not allow electric current to flow through it.

CURCUIT - A path for electric current to flow.

CLOSED CIRCUIT - A continuous path for electric current to flow.

PARALLEL CIRCUITS - A way of connecting two or more electrical parts so that the electric current flows equally through each part

SERIES CIRCUIT - A way of connecting electric parts so that electric current flows along a single path.

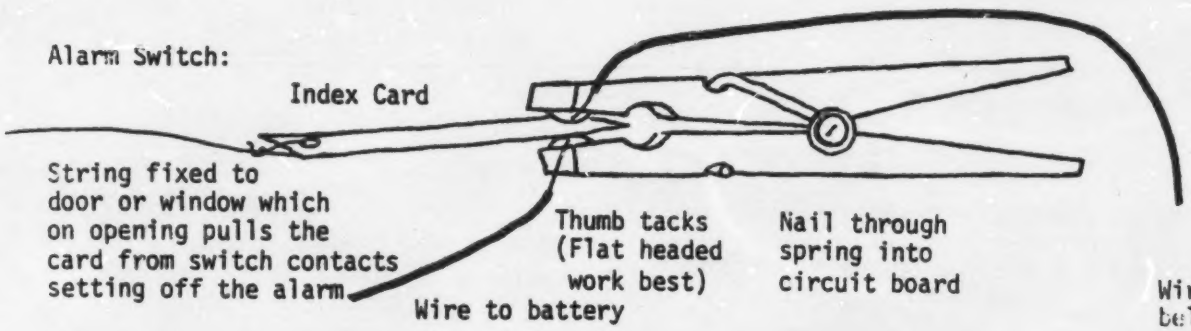
RESISTANCE - The oppostition which a device or material offers to the flow of electric current. Heat generally results when a resistance is placed in an electrical system.

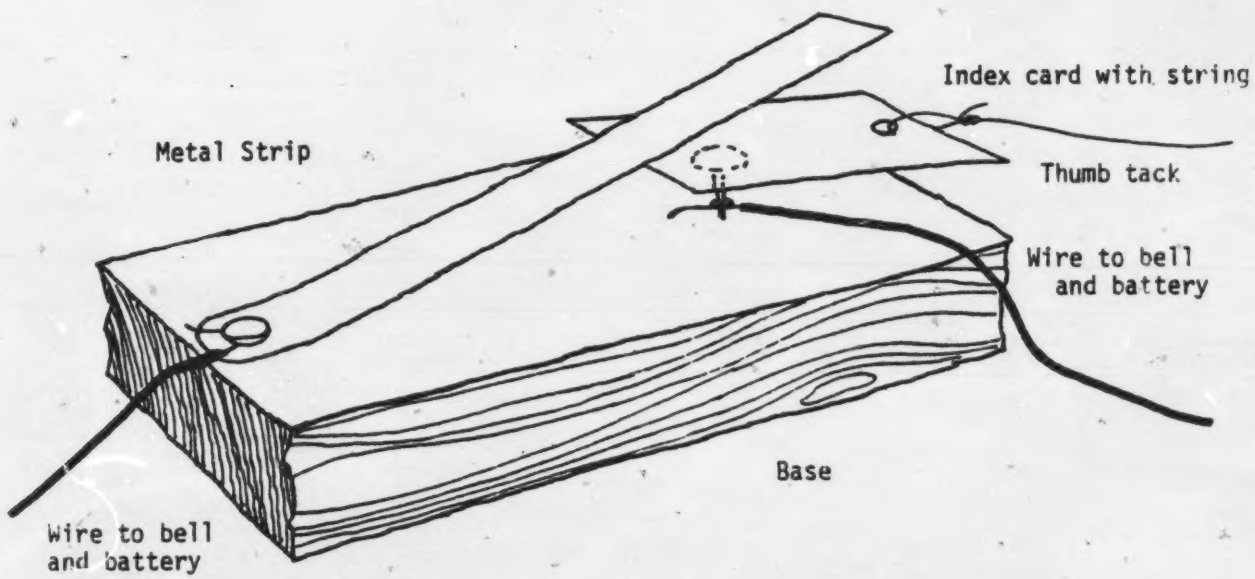
VOLTAGE - Electrical pressure that makes current flow

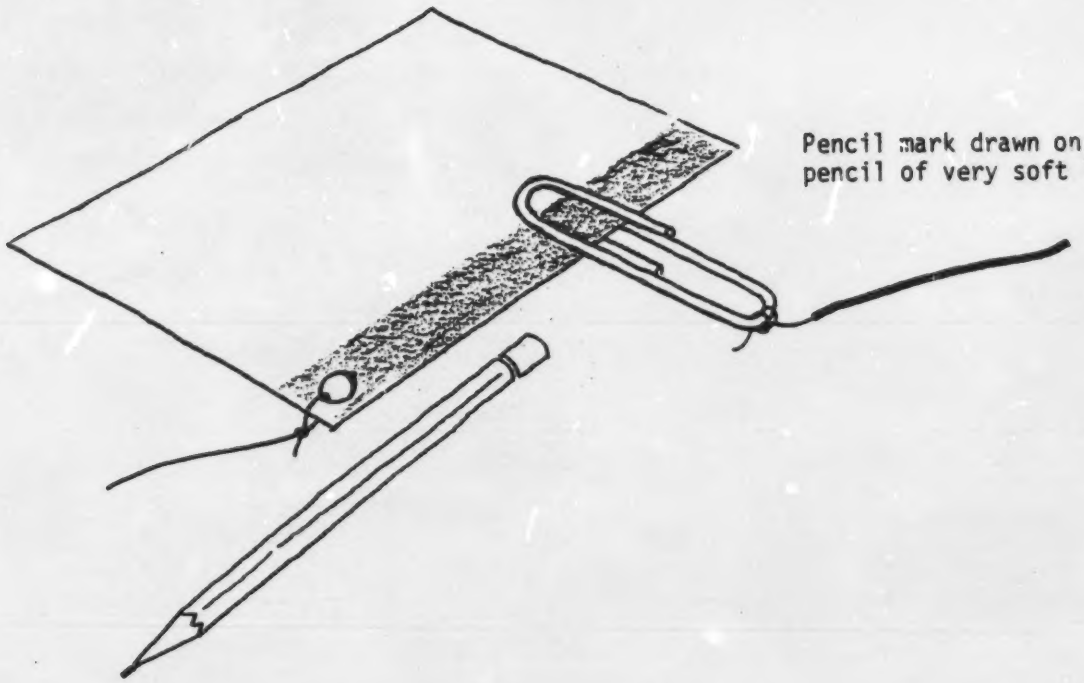
ALARM DESIGNS:

Several possible student burglar alarms and component parts are shown below. These are by no means the total. They are shown only to give you some clues of what your students will show you during the design stage of the project. It is important that your students develop their own drawings (not the ones shown here).

Alarm Switch:

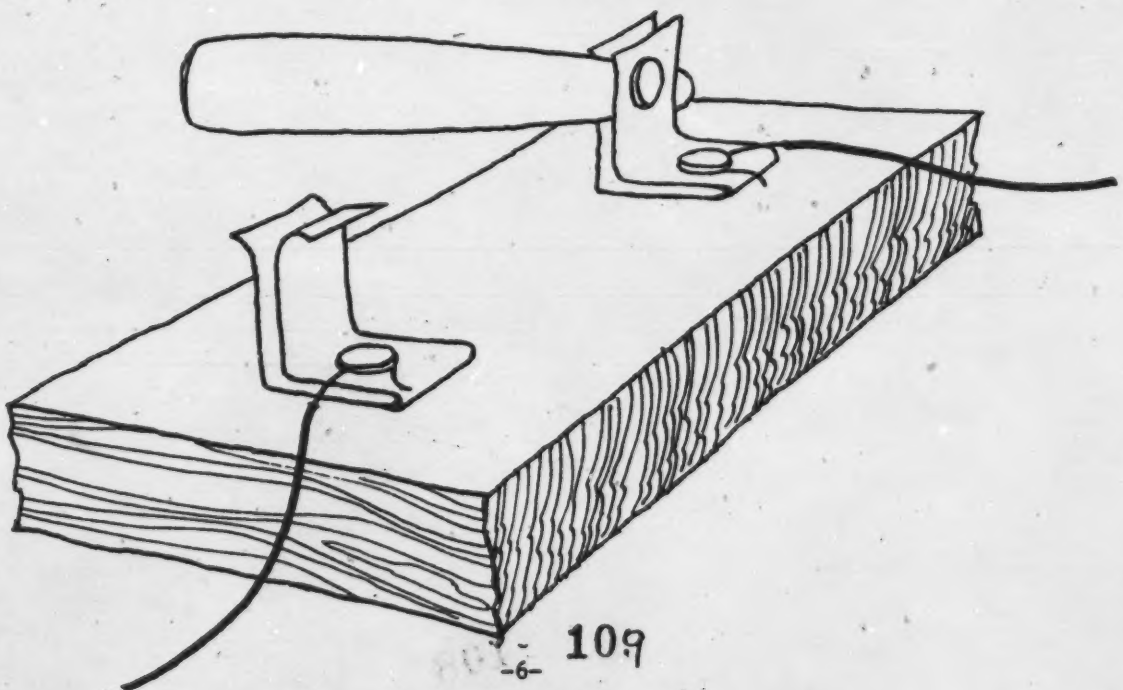

Index Card
String fixed to door or window which on opening pulls the card from switch contacts setting off the alarm
Thumb tacks (Flat headed work best)
Nail through spring into circuit board
Wire to battery
Wire to bell



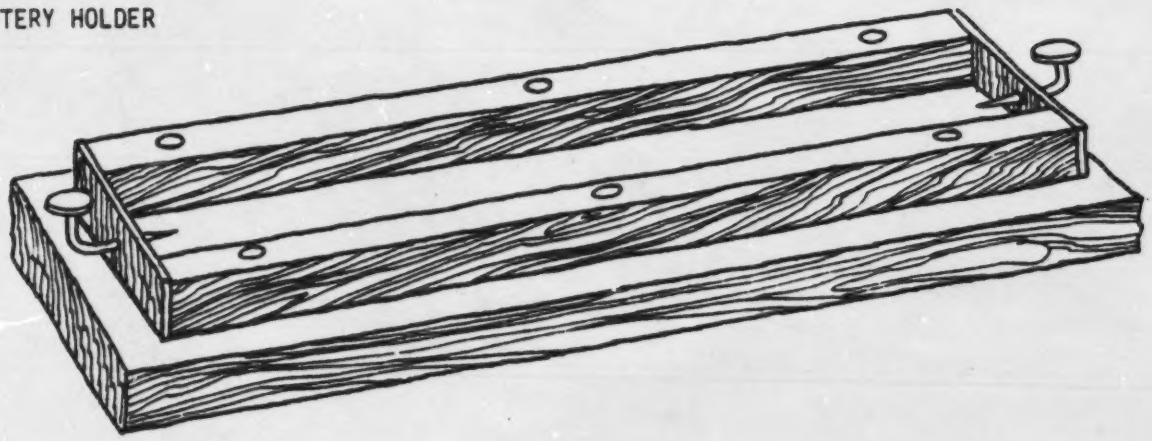


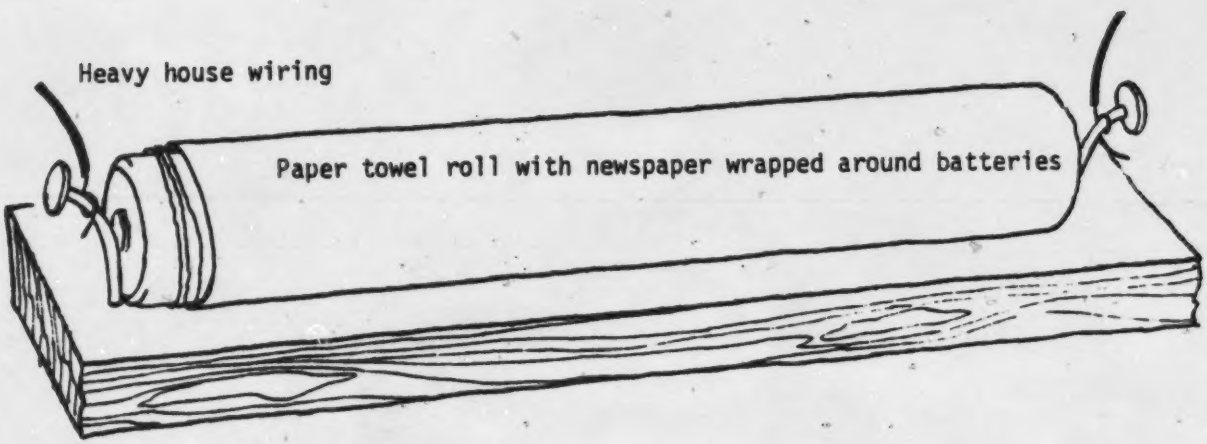
Pencil mark drawn on with a pencil of very soft lead

Cut from top of tin can with tin snips, bend pieces with pliers.

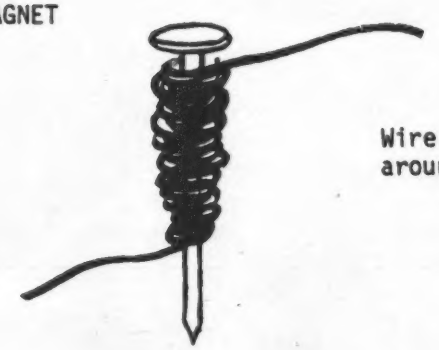


BATTERY HOLDER





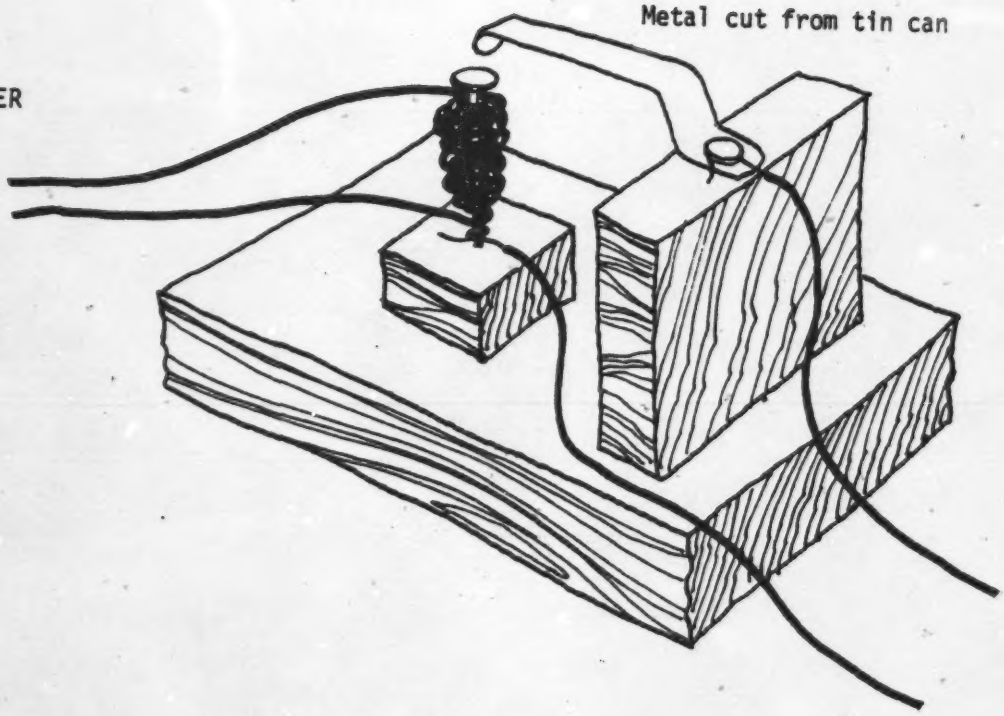
ELECTROMAGNET

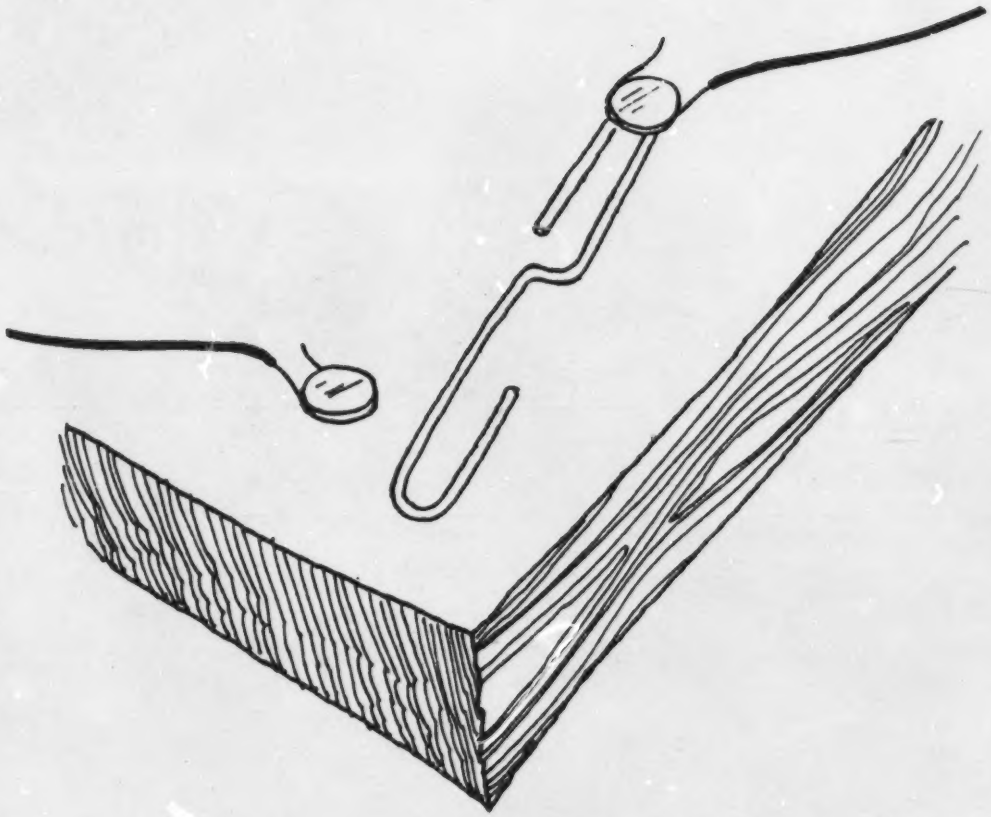


Wire wound a number of times around a nail.

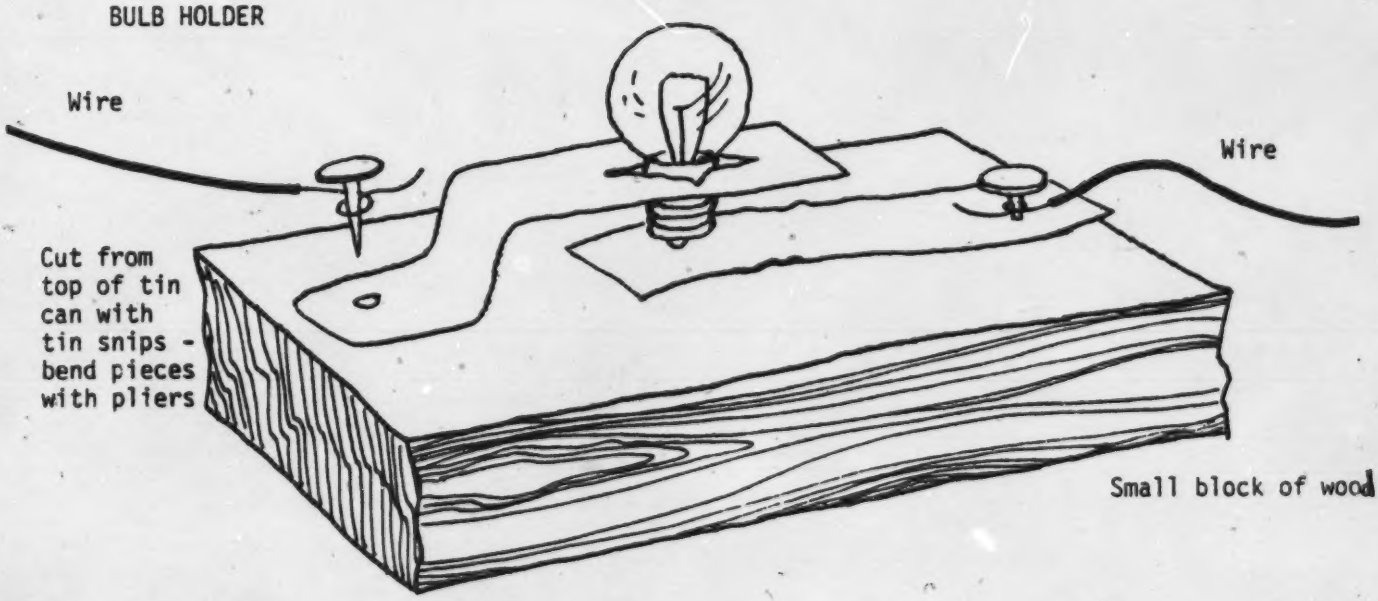
BUZZER

Metal cut from tin can

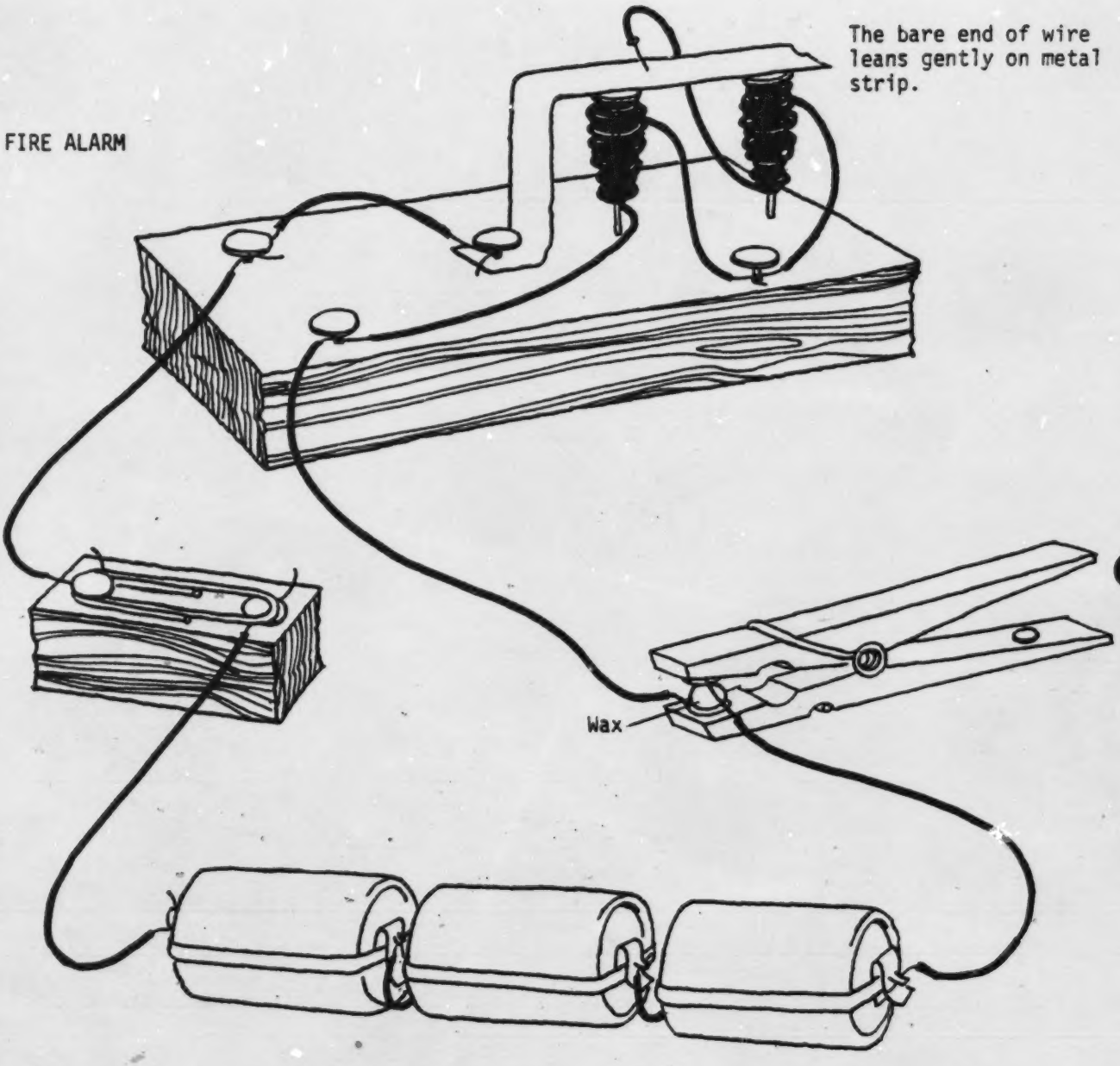




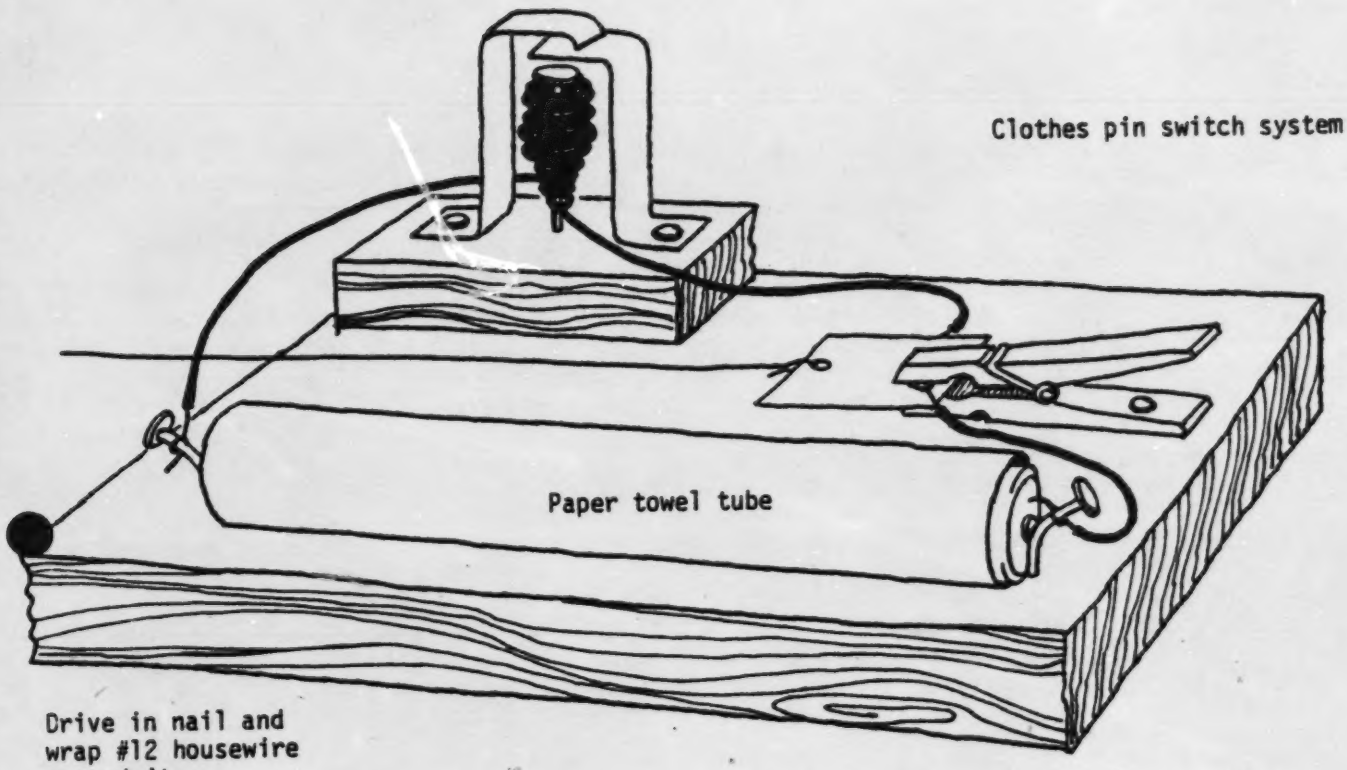
BULB HOLDER


Wire
Wire
Cut from top of tin can with tin snips - bend pieces with pliers
Small block of wood

FIRE ALARM



Clothes pin switch system



Drive in nail and wrap #12 housewire around it.

6 - 1 1/2 Volt Batteries within paper towel roll.

The tube will be too big so roll newspapers and make tube within tube.

PROCEDURES:

There are a number of ways this experience can be introduced. A discussion of things taken from the desks or classroom is one way to begin. A discussion of major robberies in an area (from newspaper) is another way to begin. Others include: a fire drill (alarm system); alarm systems in neighborhood stores

(Lead in questions)

1. What might we do to warn us when a theft is being made? (Discussion to lead toward burglar alarms)

2. Do you think you could make a burglar alarm?

3. What are some steps you must take? (List suggested steps on chalkboard.) A possible sequence is shown here for your use. You may want to list only a and b below and assign each student to draw an alarm design as a first lesson.
   a. Decide what you want to protect - eg door, window, desks
   b. Draw a design of what the alarm might look like
   c. Draw a picture of the circuits
   d. Gather the equipment
   e. Build the alarm
   f. Modify the alarm to make it better

(Making the drawing)

4. If you list each step above you might want to do only a and b as a first assignment.

5. Begin the next session by examining some of the drawings. (You will probably find the drawings lacking in detail or have been sloppily done)

(Follow-up question)

6. Hold up drawing. Ask, "Could you follow this drawing to do the experiment shown? (conclude, with students, that they try to make clearer drawings) (You might show them light bulbs, batteries, etc. to use as patterns)

7. Pass out Diagram & Symbol Chart. Suggest using symbols to represent different parts.

8. You might suggest to the students at this point that they look for alarms when they visit different stores. Better yet a store, with an alarm system, might be within walking distance of your school...take your class.

(Gathering Material)

9. Once your students have had a chance to draw their design you have the choice of everyone constructing their own, or establishing teams. Teams can be arranged by pairing students with similar drawings. The next step then is to gather materials and construct the system.

10. Suggest to your students they seek their materials from a variety of sources.

Home -	School -
flashlight bulbs	simple electrical
batteries	items
wire	
aluminum foil	
wood	
nails	
tape	

11. You may want to check the Science Kit Center for certain items.

(Constructing Alarm Systems)

12. Once the individual students or teams have gathered their material, allow them to proceed. You might want to ask some of the following questions.

"Would it be better to have a light go on instead of off when the window is open?" (this will lead to electromagnets)

"How many batteries work best with your design? (this may lead to parallel and series circuits)

"Is it better to have a buzzer or a light?"

"What kind of switch works best?"

"Is the bell a good alarm?"

"How can the system be reset?" "or reset itself?"

BATTERIES AND BULBS II

GRADE 6

KIT

32 bulbs
32 bulb bases
32 batteries
32 battery holders with fahnestock clips
1 roll insulated wire
1 roll copper wire
1 roll enamel insulated wires
32 magnets
4 prs. tin snips
4 pieces sandpaper
16 compasses
4 pr. wire cutters
Batteries & Bulbs II - 5 copies
3 saws
5 hammers

NON-KIT

wood
nails
clothes pins
metal
pencils
paper clips
misc. items--depending on student interest
aluminum foil
cans
tubes from paper towels and toilet tissue
diodes--#1N34--available locally
earphones (see p. 111)
masking tape
corks
thumb tacks